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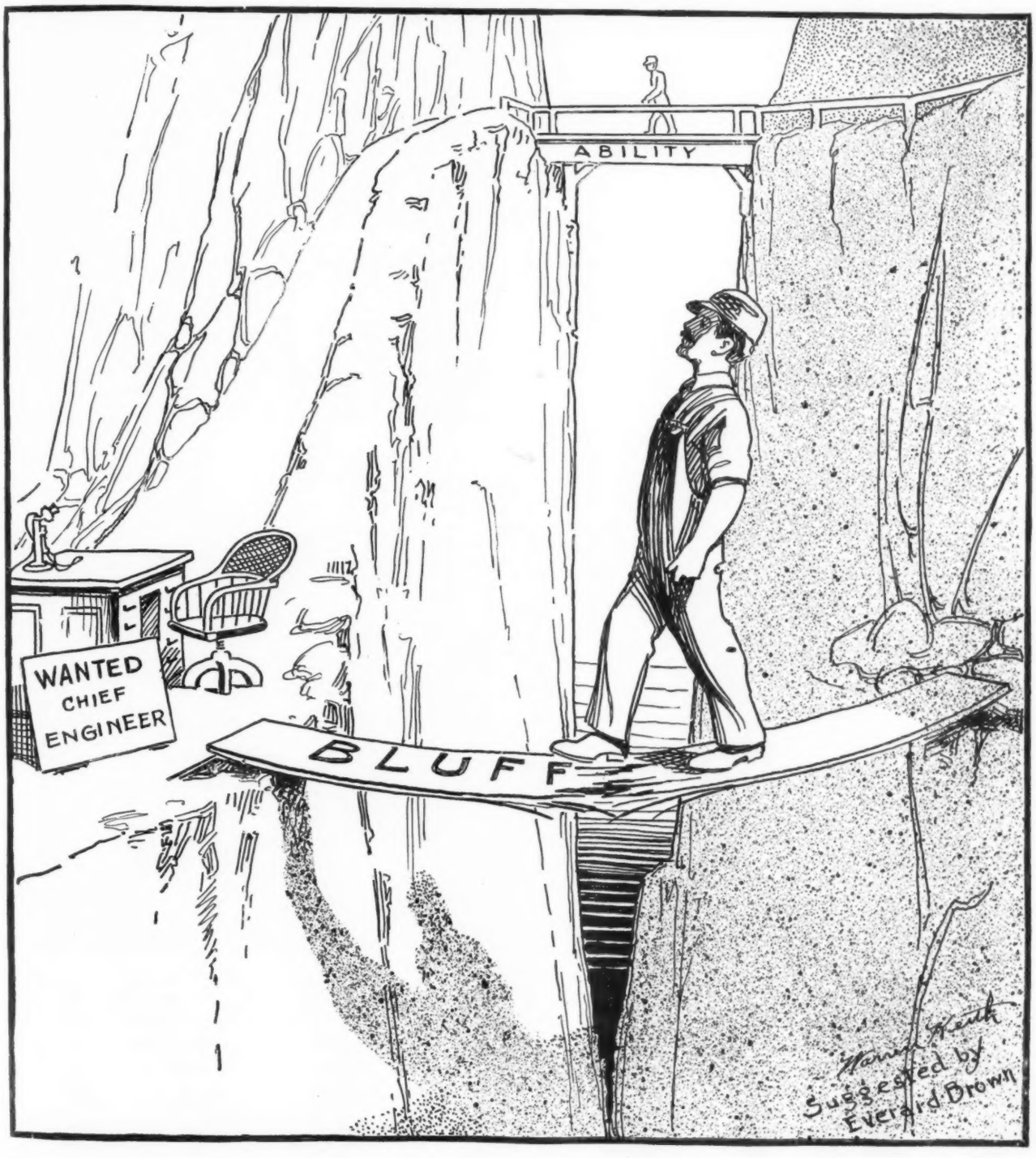


THE LONGER WAY IS SAFER

Fairview Sewage-Pumping Station

By Thomas Wilson

SYNOPSIS—An attractive plant equipped with angle-compound-centrifugal pumping units. Its capacity is 150,000,000 gal. in twenty-four hours. The efficiency of the pumps is 70 per cent. The equipment cost $118,000.

One of Detroit's show plants, put in commission in October, 1912, is the Fairview sewage-pumping station. The machinery is neatly arranged and kept in excellent condition. The boilers wear a "dress suit" of white enamel brick, which with metal trimmings at the corners and across the front add to the general attractiveness of the boiler room.

The building itself is of the classic style of architecture to harmonize with the surroundings, as eventually the plant will be in a residence district. Buff Roman brick walls trimmed with terra cotta are reinforced by a steel frame. Concrete slabs covered by red tile form the roof. Within, a wainscoting of white glazed tile, walls of gray face-brick, a floor paved with red tile, steel doors, electroplated railings and Fenestra steel sash lend an attractive appearance.

The plant is located at the foot of Parkview Ave., near Waterworks Park, and 234 ft. back from the harbor line. It was designed to raise domestic sewage and storm water from a 9-ft. sewer draining 3500 acres of residence property and discharge it into the Detroit River. The sewage enters a screen chamber, shown to the left of the main building in Fig. 2, and passes on to a water gallery formed between the building foundation and a division wall in the basement. This well is 137 ft. long, 40 ft. deep and 9 ft. wide. As shown in Fig. 1, the sewage flows by gravity into the suction of the pumps and through cast-iron pipes is raised 36 ft. to brick outlets discharging into the river. Hydraulically operated gate valves are placed in the discharge lines.

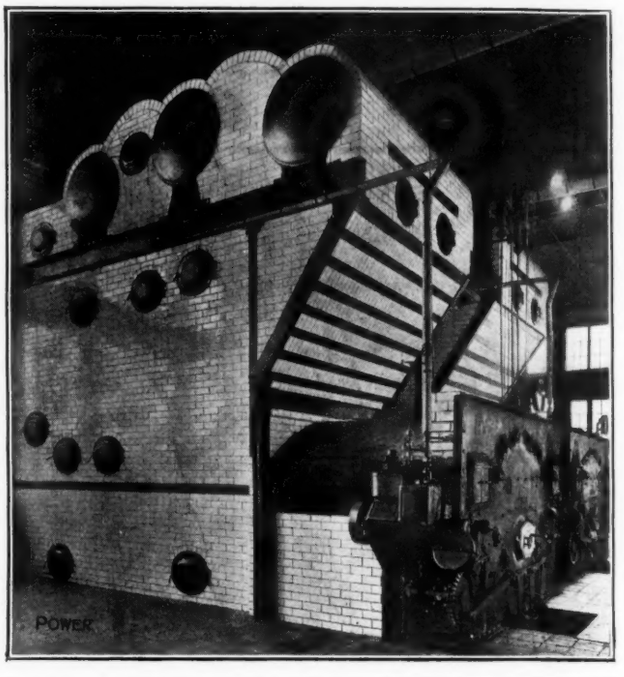


Fig. 3. Boilers in Their Dress Suits of White Tile

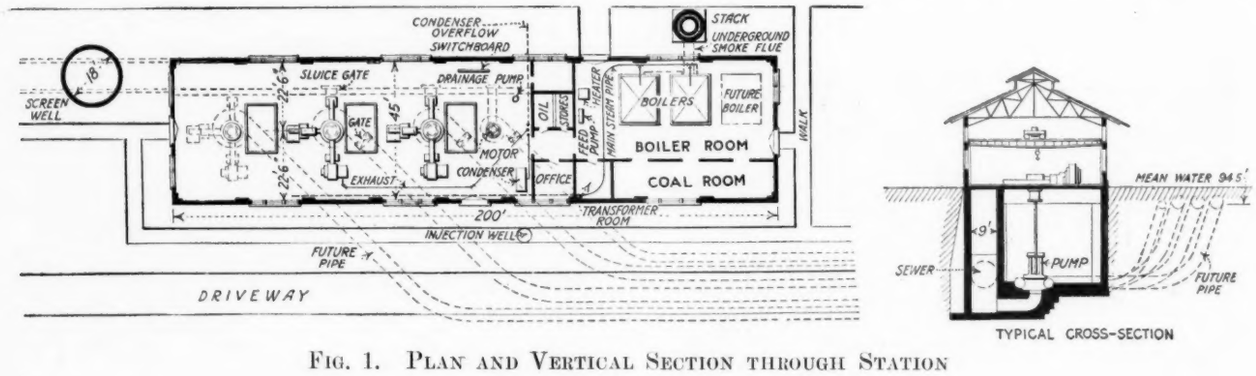


Fig. 1. Plan and Vertical Section through Station

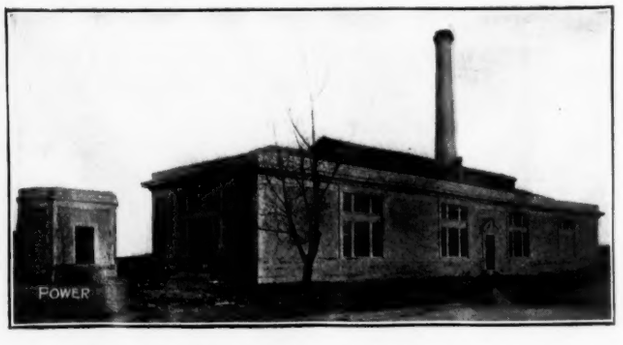


Fig. 2. Fairview Sewage-Pumping Station

The pumping equipment consists of two steam-driven units, each having a capacity of 100 cu.ft. per sec., and a motor-driven pump capable of delivering 30 cu.ft. per sec. Provision has been made in the design of the plant for the future installation of a third steam unit. The pumps are of centrifugal type set horizontally with vertical shafts and half imbedded in the concrete of the basement floor. Two are 42-in. units and the third is a 24-in. pump, the suction connections to the water gallery being 54 and 36 in. diameter, respectively. The large pumps are driven by variable-speed angle-compound engines, 18 and 36 by 36 in., which, at 150 lb. gage pressure, 18 lb. receiver pressure, a vacuum of 25 in. and a speed of 100 r.p.m., indicate 500 hp. The steam supply

pipe is 6 in. diameter, the high-pressure exhaust 10 in. and the low-pressure exhaust 12 in. All piping except the loop to the throttle is underneath the floor. Connection between engine and pump is effected by a 9½-in. vertical shaft 40 ft. long. Near the center of its length a bronze and cast-iron thrust bearing carries the weight of the shaft. The bearing runs in oil and is provided with a water jacket which may be used if needed on long continuous runs. Ordinarily, the oil keeps the bearing cool.

water-tube boilers are installed, with space for a third unit. Top-feed stokers with a projected grate area of 48 sq.ft. serve the boilers. City water is used as boiler feed, as the river water supplied to the condenser is muddy and unsuited for the purpose. Either a duplex pump or an injector handles the supply, which is raised to a temperature of 200 deg. in an open heater, taking exhaust steam from the feed and condenser pumps.

Meadowbrook run-of-mine coal is burned. It is stored in a 200-ton bunker in front of the boilers and delivered

PRINCIPAL EQUIPMENT OF FAIRVIEW SEWAGE PUMPING STATION

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Engines	Angle, compound	18 and 36 by 36-in.	Drive cent. pumps	Steam press. 150 lb., vacuum 25 in., 100 r.p.m.	Wisconsin Engine Co.
2	Pumps	Centrifugal	42-in.	Main units	Capacity 100 sec.-ft. against 36 ft. head	Camden Iron Works
1	Pump	Centrifugal	24-in.	Main unit	Driven by 150 hp. Westinghouse motor, 360 r.p.m.	Camden Iron Works
1	Condenser	Barometric	16-in.	Serving engines	River injection water, vacuum, 25-in.	Camden Iron Works
1	Pump	Centrifugal	6-in. discharge	Water to condenser	Driven at 350 r.p.m. by 8x10-in. Shepherd double engine	Camden Iron Works
1	Pump	Centrifugal	2-in. discharge	Sump pump	Driven by 5-hp. Westinghouse motor, 1120 r.p.m.	Camden Iron Works
1	Crane	Traveling, hand operated	14 tons	Serves main pump room		Northern Engineering Co.
2	Boilers	Vertical water-tube	300 hp.	Generate steam	150 lb. press., sat. steam, stokers	Babcock & Wilcox Co.
2	Stokers	Top feed	Projected area 48 sq.ft.	Serving boilers		Detroit Stoker Co.
1	Pump	Duplex	8x5x10-in.	Boiler feed pump		Canton-Hughes Pump Co.
1	Injector		2½-in.	Boiler feed		Penberthy Injector Co.
1	Heater	Open	600 hp.	Heat feed water	Use exhaust steam from pumps	Warren Webster & Co.

A barometric condenser maintains a vacuum of 25 in. on the engines. Cooling water is obtained from the river and is forced to the condenser head by a centrifugal pump driven by a double 8x10-in. vertical engine at a speed of 350 r.p.m.

The 24-in. pump is directly connected to a 150-hp., 550-volt, three-phase motor, having a speed of 360 r.p.m. Current at 6500 volts, supplied from the public lighting plant, is stepped down to the proper voltages for the motors and lamps in the station. The ordinary dry-weather flow is handled by this unit, which, due to the

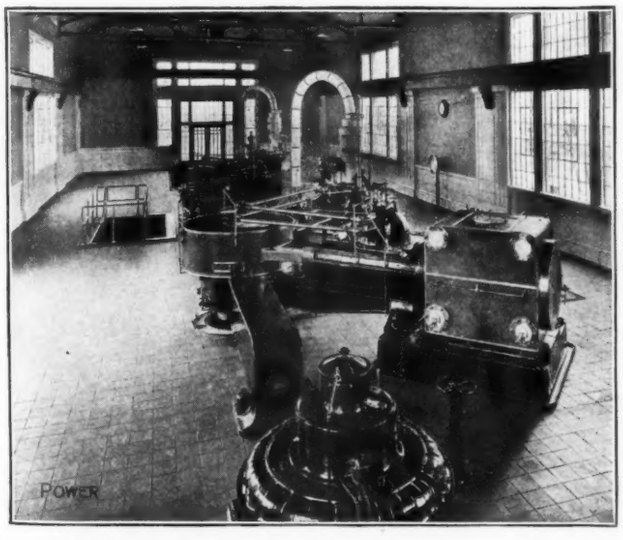


FIG. 4. ANGLE-COMPOUND PUMPING ENGINES

large capacity of the water chamber, may be shut down during peak loads at the source of electric supply. The plant is operated on three shifts per day and ordinarily an hour and a half of pumping on each shift will dispose of the sewage. It is necessary, however, to keep the boilers banked and the steam units ready for service, as a heavy storm would soon supply enough surface water to tax the capacity of the station.

In the steam-generating part of the plant, two 300-hp. by hand to the stokers. Over the top of the bunker a ¼-ton electric hoist is suspended from an 8-in. I-beam. The track extends out of the south end of the building where coal is delivered by wagon. Eventually a dock will be built and coal will be delivered by water.

Due to the intermittent operation, satisfactory operating data are not available. In the guarantee the pumps were to have an efficiency of 70 per cent. and the engines to develop an indicated horsepower-hour on 14 lb. of saturated steam. The three units have a total capacity of 150,000,000 gal. in 24 hr. The building cost $144,000, the site $20,000 and the equipment $118,000. Per million gallons of daily capacity, the total equipment of the station cost $786.66. Smith, Hinchman & Grylls, of Detroit, were the architects and engineers for the station and Charles Meny is chief engineer of the plant.

The Rate of Radiation from bare steam pipes is approximately 3 B.t.u. per hr. for each square foot of surface exposed to a temperature difference of one degree between the steam inside the pipe and the air surrounding it. Therefore, the square feet of surface multiplied by the temperature difference (inside and outside of the pipe) multiplied by the constant 3 gives the total loss in B.t.u. per hour from a given pipe.

Interesting Accounts are to hand from Sweden regarding the results of trials lately conducted by a leading Swedish company on two sister steamers, one, the "Mjölner," being fitted with turbo-electrical engines and the other, the "Mimer," with ordinary triple-expansion engines. Each is of 2225 tons displacement and designed for a speed of 11 knots, a stipulation being that in each case the engines were to develop 900 i. hp. The most important factor, however, was with regard to the consumption of coal, which was guaranteed to be 30 per cent. less in the turbo-electrical vessel than in that fitted with the triple-expansion engines. For the trial trip, which lasted seven hours, the screws of the "Mimer" were fitted to the "Mjölner," so as to avoid possible difference arising from any difference in construction. During the trip the turbo-electrical engine developed 975 i. hp., or 75 more than the guaranteed maximum, while the average speed was 11.8 knots, as against 11 guaranteed. Good as these results are, the small consumption of coal exceeded the most sanguine expectations, amounting to 0.4 kg. per indicated horsepower, which works out at 35 per cent. less than the consumption on the sister ship, the "Mimer." Both steamers are to be employed in the coast trade and their hulls have been especially constructed for navigation on the ice.—"The Engineer."

Interesting Steam-Pipe Installation

By Hubert E. Collins

SYNOPSIS—Two old boiler plants are piped to give a common steam supply and to equalize the load on each. Details of the pipe-line construction are given.

The United Piece Dye Works, Lodi, N. J., were confronted with the problem of maintaining operation with an insufficient boiler capacity in one of the mills during the past winter and space did not permit of putting in more boilers. A larger plant, however, had some capacity to spare which would be of assistance to the other if properly connected. The two boiler plants were not far from 1500 ft. apart, and it was decided to connect the headers of the two boiler rooms with two 6-in. steam lines. The combined capacity of these two boiler rooms is around 3000 hp. Mill *A* has about 2000 boiler-horsepower capacity.

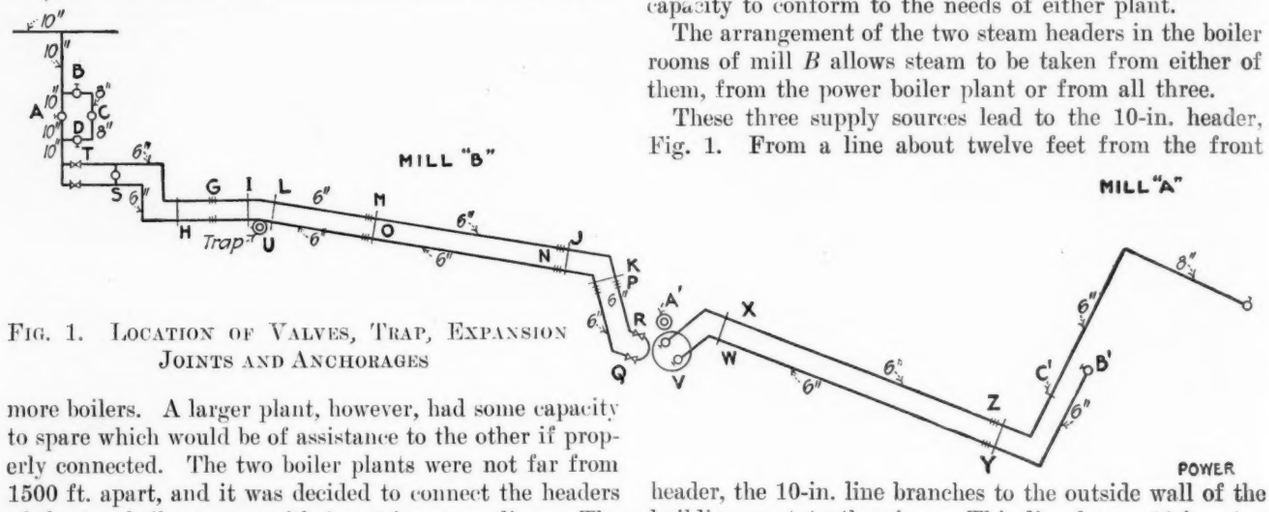


Fig. 1. Location of Valves, Trap, Expansion Joints and Anchorages

The boilers in mill *B* are connected to two headers, one over the front and the other over the rear of the settings. The power plant in mill *B* is connected to a single header, which is connected to the mill boiler headers with a 6-in. bleeder. These three headers are the sources of steam supply, connected as shown in Fig. 1.

The 6-in. header from the power plant runs into the one over the front of the boilers in the mill plant and the two headers there are connected with a 10-in. header. As this combined boiler plant carries 120 lb. pressure and the boilers at mill *A* 75 lb., a reducing valve is situated at the mill *B* end of the pipe line.

Equalizing Steam Lines

The lines connecting these two boiler plants are called equalizing steam lines, as the purpose is to equalize the capacity to conform to the needs of either plant.

The arrangement of the two steam headers in the boiler rooms of mill *B* allows steam to be taken from either of them, from the power boiler plant or from all three.

These three supply sources lead to the 10-in. header, Fig. 1. From a line about twelve feet from the front header, the 10-in. line branches to the outside wall of the building next to the river. This line has a 10-in. stop valve *A*, which is bypassed through an 8-in. reducing and regulating valve *C*, with stop valves *B* and *D* on each side of it. At the point where the 10-in. line comes outside the wall over the smoke breeching, two 6-in. lines are taken through two 6-in. valves. These two lines run parallel to the mill *A* boiler plant. From the 10-in. header they run at right angles horizontally to the wall of the power boiler plant, turn at a right angle and pass over the smoke flue on to the corner, then another right-

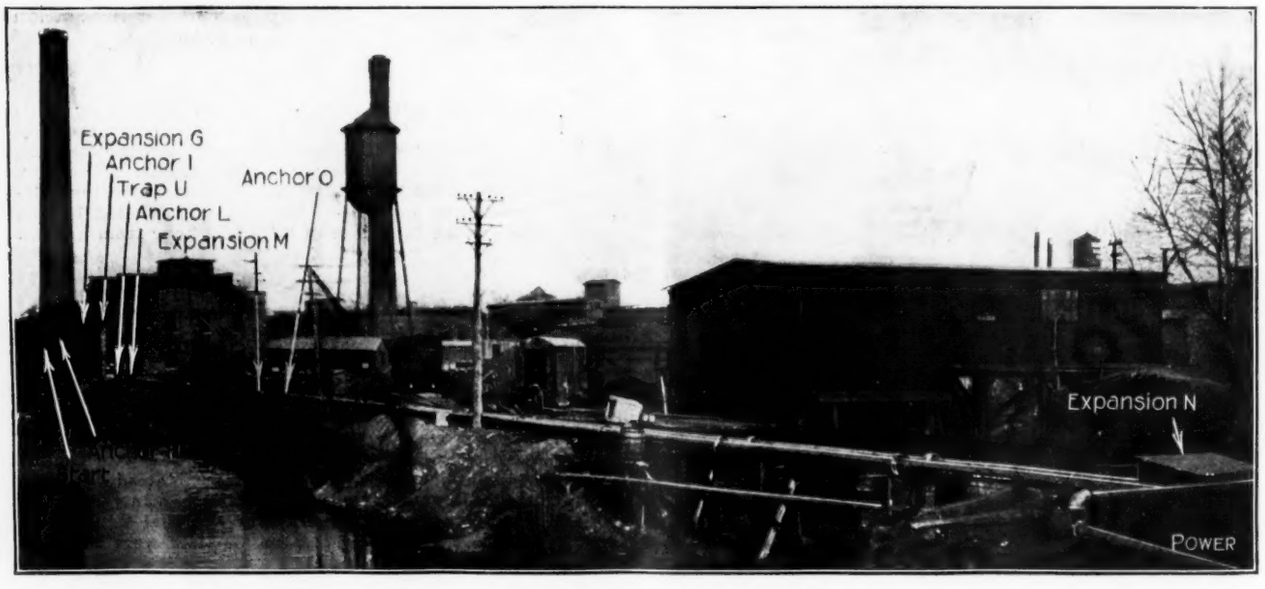


Fig. 2. Steam Mains from Mill Boiler Plant

angle turn and along to a point midway of the engine-room wall, where they drop to the level of the river bank. The lines are supported on brackets made fast to the wall of the building, and are pitched in the direction of flow with a fall of 1 in. in 15 ft.

FIG. 3. TWO STEAM LINES RUNNING UNDER A BRIDGE

The pipes are anchored at the first corner of the power boiler-plant building and near the pier support outside the engine room, where they take the first drop. Midway between these anchorages *H* and *I* is placed the first slip expansion joint *G*.

After the first drop the lines run horizontally along the river bank on wood supports. At the bottom of the first fall is placed a tee on each line that acts as a drop-leg, from which the drippage is removed. The lines are pitched down along the river bank in the direction of flow, 8 in. to 15 ft., to a point beyond the railroad trestle (Fig. 2), also at the turn between the anchors *J* and *K* (Fig. 1). At the first support from the power boiler plant and the engine house is the anchor *L*. The distance from these third anchors to the fourth set on the river bank is 256 ft. A set of expansion joints *M* is placed in front of the fourth anchorage. From fourth to the fifth anchorage is 237 ft. and the expansions *N* are placed just in front of the anchorage *J*.

Fig. 2 gives a view of the steam lines as they come from mill *B* boiler plant around and along the wall of the power boiler plant to the point where they drop to the ground surface and along the river bank to the expansion *N*, at which point they turn to run under the bridge to reach the yard of mill *A*. At the extreme left of Fig. 2 can be seen the smoke flue, over which these steam lines pass. The pipes are supported on the walls above the ground by brackets. At the extreme right is the housing for the expansion joints *N*.

Ten feet beyond this the lines drop 24 in., then turn to go under a bridge. At the first support after turning from the railroad track is the anchorage *J*. Just beyond is the expansion set *P*. The lines run under the bridge with a fall of about 1 in. in 15 ft. and next to the retaining wall of the mill *A* side the drop is 24 in. At this point the lines turn at another angle and pass through this wall underground to the receiver room, where just inside the wall in the pipe tunnel are placed the valves *Q* and *R* on the horizontal runs. From these, the lines are joined in a Y and empty into a receiver, which catches all drippage from the valves *S* and *T*. It also takes care of the drippage from the vertical lines over the receiver, and which is dropped by the trap *U*, placed in the receiver pit. From the receiver the lines are taken from a Y on the top. Two 6-in. valves *V* and *W* are placed on the top of this Y and from these valves the lines extend through the roof of the receiver house and are carried over the roof of the adjacent buildings.

Fig. 3 shows the two steam lines near the point where they turn toward the bridge, looking toward the trolley bridge and mill *A* yard from the mill *B*. The first pipe is for water; the two steam lines are just back of it.

Fig. 4 shows the steam pipes passing from under the bridge through the concrete abutment in front of the receiver house. The steam lines in this view are the ones on a line with the lower side of the bridge girders. The steam pipes are also shown as they leave the receiver house to the level of the roof of the adjacent building and rest on the roof supports.

At the second roof support is placed the anchor *X* (Fig. 1). The pipes have a fall of 1 in. in 15 ft. over the roofs of the buildings and are pitched down from the point over the receiver house. Fig. 5 shows the lines on the roofs from the point over the receiver house almost to

FIG. 4. VIEW FROM THE OTHER SIDE OF THE BRIDGE

the first turn, shown in Fig. 6 at the extreme left. On the second support beyond this turn (not shown) is placed anchor *Y*, Fig. 1, and in front of it is the expansion *Z*.

On the edge of the roof at the alleyway the lines break at right angles horizontally and run over the alleyway roof. One line feeds the finishing-room side of mill *A*, going through the roof of the alleyway to the finishing-room steam main, which runs horizontally and at right angles to the equalizing lines just under the roof. Just in front of this break in the line is a drop-leg, to which is attached a trap, and next to this drop-leg is the valve

B'. The 6-in. drop-leg ends in a blank flange, from which the drip line is taken to the trap in the basement almost underneath the drop-leg. The other equalizing line supplies the dye house and runs across the roadway in front of the alley, turns at right angles horizontally for a few inches and then drops to the 8-in. dye-house main. At the second support over the alley is placed the anchor *C'* on the dye-house main only. Expansion in the finishing-room main is taken care of by the drop

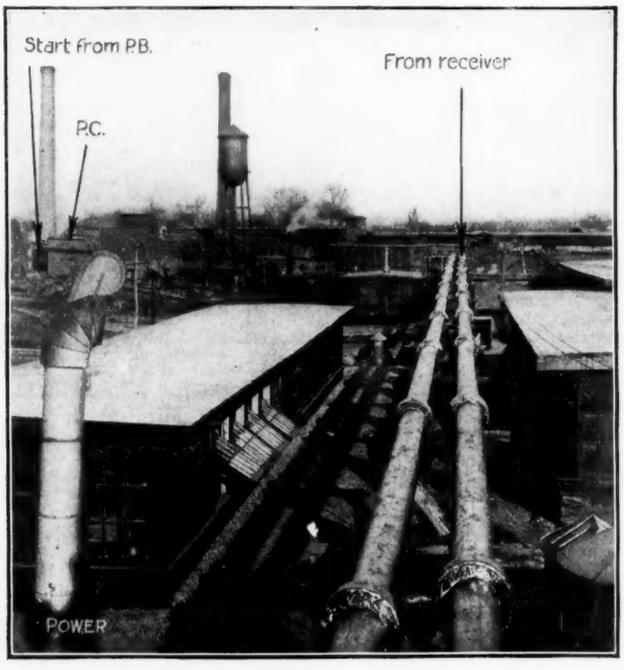


FIG. 5. PIPE LINES ON ROOF

through the roof of the alleyway. The expansion in the dye-house main beyond the anchor *C'* is taken care of at the drop to the 8-in. main, which forms a swing joint.

DETAILS OF CONSTRUCTION

The details of construction of the line and its accessories are of interest, because some of the conditions met were outside the average experience.

The installation of these lines offered many difficulties, as much of them were exposed to the weather. A study of Fig. 1 and the other illustrations will show as few turns and bends as circumstances would allow. The exposure to the weather required care as to the drainage and the amount of pitch given seems to have been adequate.

The supports were required to carry an average of 530 lb. each when spaced 15 ft. apart. Figs. 7 and 8 show the type of the ground and roof supports, respectively.

The ground supports have a plank 10 in. by 5 ft. on the bottom to take the weight. They are bedded on stone or brick. The two side braces are buried in the earth and thus take up any lateral thrust in the direction of the pipe lines.

The roof supports are braced to take this thrust. In order to distribute the weight on the roof as much as possible, a continuous line of plank was placed under the legs of the supports.

Fig. 9 represents the type of support used on the side walls of the buildings that the lines skirted. A channel was placed at the back of the wall to distribute the load.

Fig. 10 shows how the anchorage of the pipe is made at the different points. It consists of a distance piece made of $\frac{5}{8}$x3-in. iron, to hold the pipe in line above the wood support, and a strap of the same size of iron to hold the pipe down.

Fig. 11 shows the method of anchoring along the river bank. In addition to the clamp on the support, there is a clamp on the pipe with a rod leading from it to a plank buried some feet in front of the support.

The pipes were covered with 85 per cent. magnesia molded nonconducting material, wired on and covered with magnesia cement on the flanges and fittings. Over the covering was placed rubberoid paper wired on and over this was sewed tarred canvas.

Settling of the supports on the river bank was looked for and taken care of by placing the loose lengths of pipe on the supports for about ten days before the roller bases were lined up. There was considerable rain during that time and therefore there was but little settling after the line was in position.

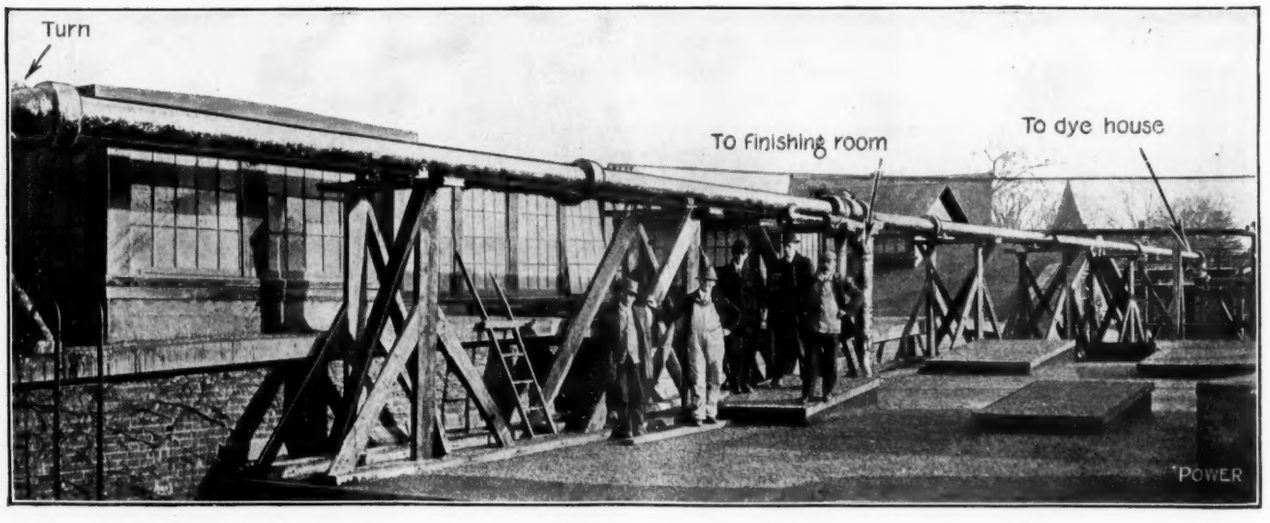


FIG. 6. NEAR VIEW OF PIPE LINES ON ROOF AND METHOD OF SUPPORTING THEM

SOME PERFORMANCES

When the steam lines were put under steam pressure, there were less than ten leaks on all this piping and only three defective flanges.

While the pipes were still bare and the temperature of the atmosphere was 30 deg. F., the lines were heated and put in commission within 25 min. without water-hammer from condensation.

After the lines were covered and in commission, the losses by condensation were checked. The two dumping traps on the line were observed to take, on an average, 8 sec. for an operation. As the amount of water discharged by each operation was known, a close estimate of the amount of condensation was secured. The trap at the receiver discharges at each operation 65 lb. of water

$$\frac{445}{18{,}990} = 2.3 \textit{ per cent. loss by condensation}$$

The chart (Fig. 12) gives some idea of the performance of the two lines. The heavy line gives the steam pressure at the source of supply at the pressure-regulating valve in mill *B*. The dotted lines give the pressures on each of the two lines at a distance close to 1300 ft. from the source of supply. One point gained by these equalizing lines was that there was a more uniform pressure in mill *A*, as shown by this chart, whereas prior to this the daily

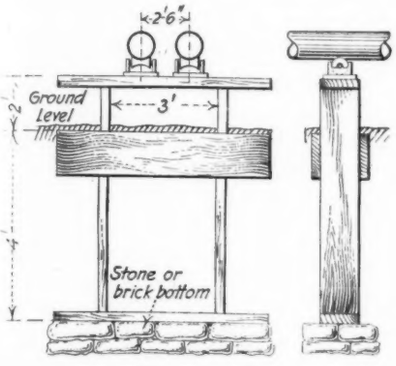


FIG. 7. WOODEN GROUND SUPPORT

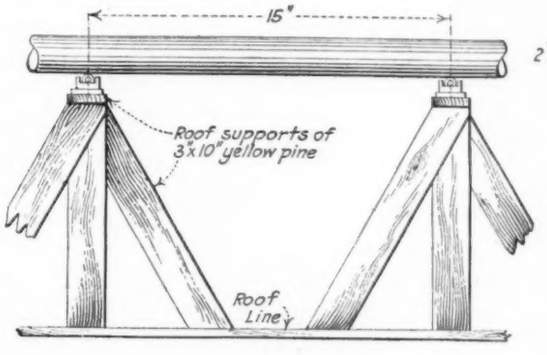


FIG. 8. PIPE SUPPORT ON ROOF

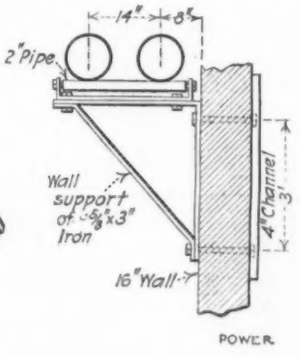


FIG. 9. WALL SUPPORT

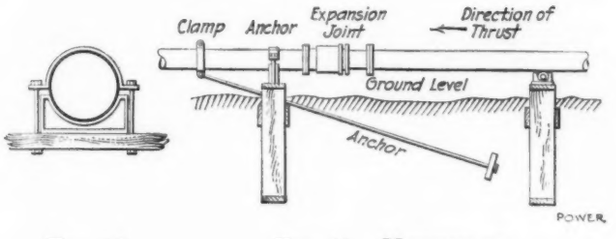


FIG. 10. ANCHORAGE

FIG. 11. METHOD OF ANCHORAGE

steam variation amounted to as high as 45 lb. pressure. The drop in pressure in the 1300 ft. of pipe can also be observed. At the point of maximum drop, the amount is 15 lb., while the two 6-in. pipes are supplying steam at the rate of 30,000 lb. per hr.

When the lines were first installed, a trap was placed on the drop-legs at the first drop outside the wall of the engine room. It was later observed that after the lines were warmed up there was not enough condensation collected at that point to operate the trap more than once or twice

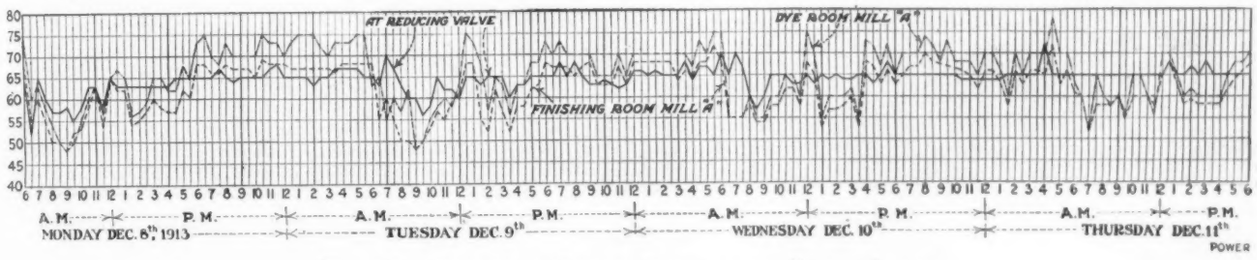


FIG. 12. CHARTS OF STEAM PRESSURE ON STEAM LINES

and number *A'* 20 lb. During a given period in December the traps were watched and it was observed that the trap *U* was operated five times per hour during the 24, and trap *A'* three times. The amount of steam flowing through the pipes was recorded by steam-flow meters.

The average amount of steam per hour for the six days of the observation was 18,990 lb.

Amount of condensation equaled:

$65 \times 5 \times 24 =$ 7800
$20 \times 3 \times 24 =$ 1440 for finishing-room side.
1440 for dye-house side.

Total for 24 hr., 10,680 lb.

$$\frac{10{,}680}{24} = 445 \textit{ lb. per hr.}$$

per day. The trap at this point was therefore disconnected and only the drip valve left to use when first warming up.

The Effect of Vanadium in plain carbon-steel castings is to increase the elastic limit about 30 per cent., giving a much higher proportion of available strength for the same ultimate strength.

An Effective Treatment by which the porosity of cement used in constructional work can be stopped and the free lime neutralized is said to be the painting of the surface with a solution of 8¾ lb. of zinc sulphate in a gallon of water. A reaction between the zinc sulphate and the free lime occurs as deeply as the solution penetrates, and by it the insoluble neutral salts, calcium sulphate and zinc hydroxide are precipitated into the pores. This priming coat should be given some 96 hr. to dry, the surface then being brushed and painted with two coats of a good cement paint.

Keeping Track of Plant Operation

By A. D. Williams

SYNOPSIS—Recording instruments and system of plant records employed at the Cleveland Municipal plant.

Economic conditions make it necessary to keep an accurate check upon each process of power-plant operation. The new municipal plant in Cleveland is provided with facilities for determining the heat value of coal and the analysis of coal, ashes and flue gases; instruments and meters are installed which either indicate or record changes in the operating conditions; and a few simple forms provide a complete report of operation.

The bunkers at the plant have a storage capacity of 3400 tons, and the coal cars are spotted on two tracks above it, the coal being dumped through steel-bar gratings which are shown in Fig. 1. Telpher weighing larries having a capacity of two tons each are used to transport the coal from the bunker spouts to the stoker hoppers. Each telpher operator turns in a report giving the weight of coal delivered to each boiler and the time of delivery. These weights are totalized for each watch and entered on the daily plant report.

This daily plant report is arranged to give a complete insight into station operation, there being twenty items to be filled in for each watch. Sixteen of these are obtained from the readings of meters or recording instruments, three are computed from other items and one is obtained by reference to a steam table. The equipment of meters and gages in this plant is interesting. Fig. 2 shows the engineer's office where eight different recording instruments are installed. The readings of the CO_2 recorder are checked every few days by an Orsat apparatus. One electric meter is found in the engineer's office; this is a graphic megowatt meter which totalizes the entire electrical output of the three main generating units.

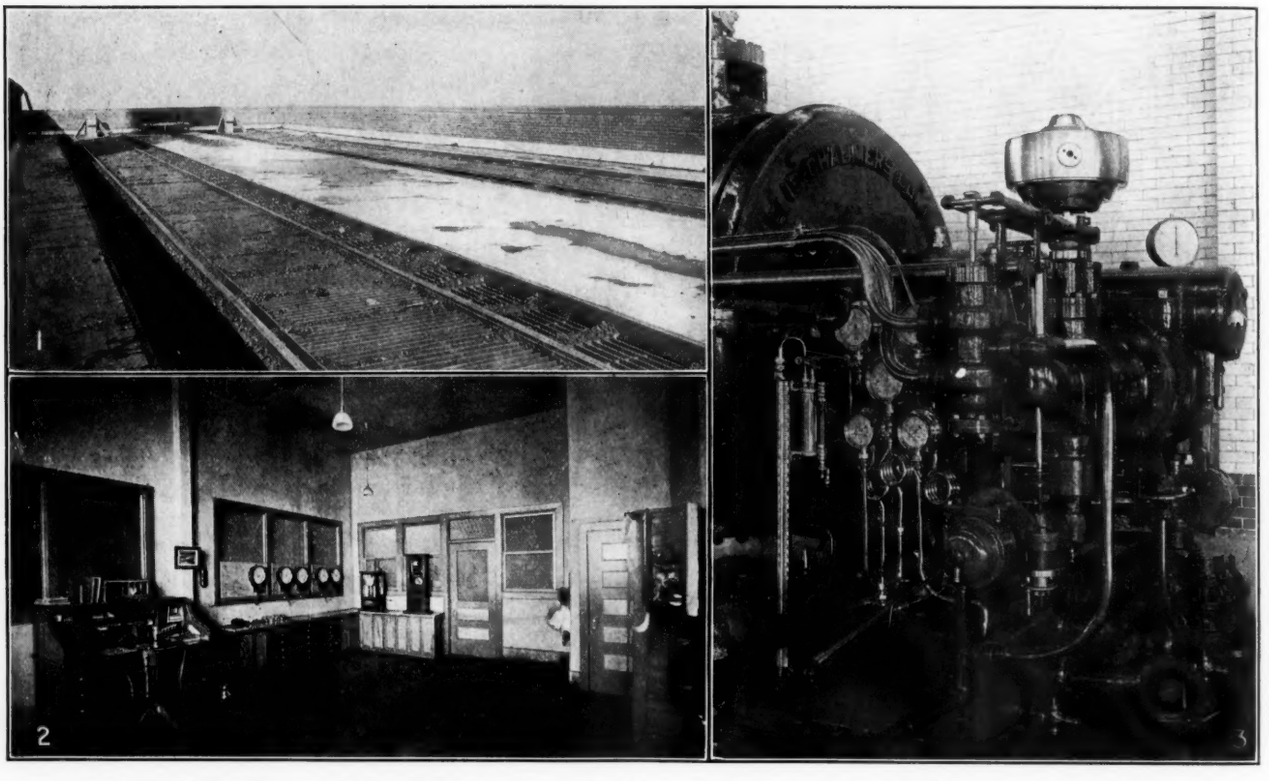


Fig. 1. Grating over Coal Bunker. Fig. 2. Office. Fig. 3. Turbine Governor and Gages

Slack coal is delivered at the plant in dump cars run on a switch over the coal bunker, and four samples for analysis are taken from each car. All the samples for each shipment are mixed and crushed, and two laboratory samples are taken—one for analysis in the laboratory, the other to be held as a check sample in case any question arises. The chemist determines the moisture, ash and sulphur content of the coal and its heat value, the last determination being made by a Parr oxygen bomb calorimeter. The price paid for the coal is based upon a specified standard of 13,000 to 13,099 B.t.u. with less than 15 per cent. ash and less than 3 per cent. sulphur. Lower heat value and higher ash and sulphur are penalized, while a premium is paid for a higher heat value. A blank form is provided upon which all shipments of coal received are reported by the chemist, together with its analysis.

The feed water for the boilers is metered or weighed by a V-notch meter having a capacity of 275,000 lb. per hour, and its temperature is recorded before it enters and after it leaves the economizers. The temperature of the flue gases is also recorded at both ends of the economizers, and the temperature of the ingoing gases is a continual check upon the combustion results obtained

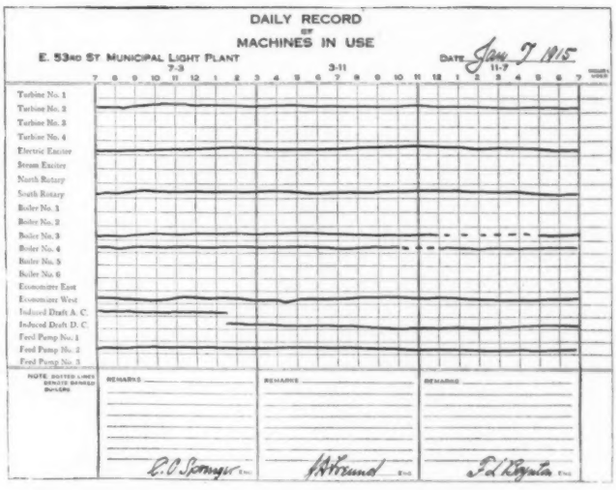
DAILY PLANT REPORT

E. 53RD ST. MUNICIPAL LIGHT PLANT. DATE

1	Water lbs. total						
2	Coal lbs. total						
3	Average CO2						
4	Temperature of fluegases entering economizer						
5	" " " leaving "						
6	" " feed water entering "						
7	" " " " leaving "						
8	" " Steam						
9	Pressure of Steam						
10	Degrees Superheat						
11	Evaporation from and at 212° total						
12	" " " " per lb. coal						
13	Total output of turbines k-w hr.						
14	Auxiliary Load k-w hr						
15	Sub-Station Load k-w hr. (11,000 volts)						
16	Local Distribution k-w hr. (2,300 volts)						
17	Station Output k-w hr. (total)						
18	Lb. Steam per k-w Generated						
19	Lb. Coal per k-w Generated						
20	Lb. Coal per k-w Output						

SIGNED

APPROVED



DAILY RECORD OF MACHINES IN USE

E. 53RD ST. MUNICIPAL LIGHT PLANT DATE Jan 7 1915

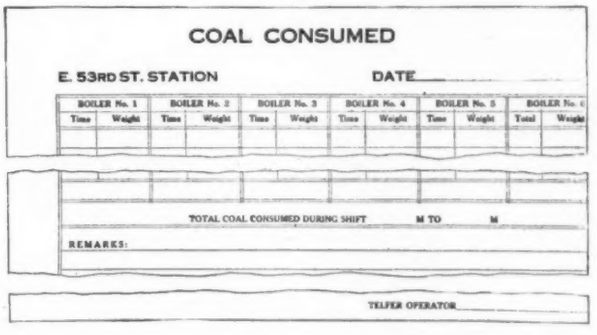
7-3 3-11 11-7

Turbine No. 1
Turbine No. 2
Turbine No. 3
Turbine No. 4
Electric Exciter
Steam Exciter
North Rotary
South Rotary
Boiler No. 1
Boiler No. 2
Boiler No. 3
Boiler No. 4
Boiler No. 5
Boiler No. 6
Economizer East
Economizer West
Induced Draft A. C.
Induced Draft D. C.
Feed Pump No. 1
Feed Pump No. 2
Feed Pump No. 3

NOTE: DOTTED LINES DENOTE BANKED BOILERS

REMARKS REMARKS REMARKS

C. O. Sprague Engr. A. Freund Engr. Ed Bigata Engr.



COAL CONSUMED

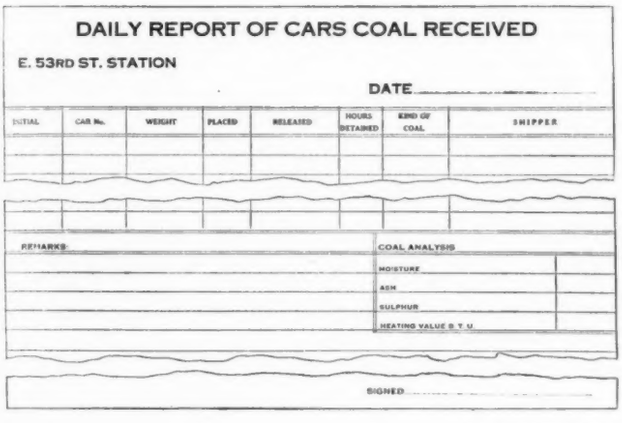
E. 53RD ST. STATION DATE

BOILER No. 1		BOILER No. 2		BOILER No. 3		BOILER No. 4		BOILER No. 5		BOILER No. 6	
Time	Weight	Time	Weight	Time	Weight	Time	Weight	Time	Weight	Total	Weight

TOTAL COAL CONSUMED DURING SHIFT M TO M

REMARKS:

TELFER OPERATOR



DAILY REPORT OF CARS COAL RECEIVED

E. 53RD ST. STATION

DATE

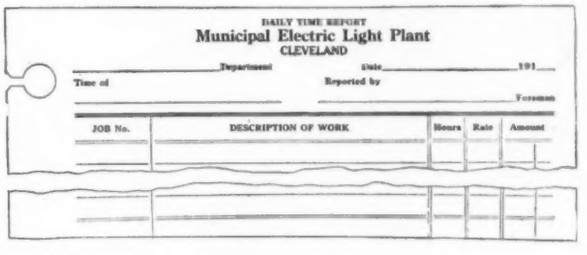
INITIAL	CAR No.	WEIGHT	PLACED	RELEASED	HOURS DETAINED	KIND OF COAL	SHIPPER

REMARKS:

COAL ANALYSIS

MOISTURE
ASH
SULPHUR
HEATING VALUE B. T. U.

SIGNED



DAILY TIME REPORT

Municipal Electric Light Plant

CLEVELAND

Department Date 191

Time of Reported by

Foreman

JOB No.	DESCRIPTION OF WORK	Hours	Rate	Amount

FORMS FOR OPERATING RECORDS

in the boiler furnace. A further check upon boiler operation is obtained from the indicating flow meter showing the steam output and by draft gages which show the draft pressure in the combustion chamber and in the boiler blast main, while the steam temperature and pressure in the header actuate recorders installed in the engineer's office. An indicating draft gage in the induced-draft fan room shows the draft at this point in the flue.

The test of the boilers and stokers developed an interesting draft feature. In these boilers, a cross-section of which was shown in POWER of Jan. 19, the combustion chamber is extremely high, resembling the well known Delray setting. The following draft readings were obtained:

Test No.	1	2	3	4	5
Per cent. of rated load.	156.87	106.53	149.54	197.86	273.83
Draft, inches of water:					
Furnace	—0.09	—0.06	—0.05	—0.09	—0.08
Top of first pass.	+0.19	+0.16	+0.22	+0.16	+0.15
Bottom of last pass.	+0.02	+0.06	+0.04	—0.07	—0.15
Upper damper	—0.10	+0.07	—0.03	—0.43	—0.95

PRINCIPAL EQUIPMENT OF METERS AND GAGES, EAST 53D ST. STATION, CLEVELAND MUNICIPAL ELECTRIC LIGHT PLANT

No.	Equipment	Kind	Use	Location	Maker
1	Barometer	Mercurial	Atmospheric pressure	Turbine room	
1	Pressure gage	Indicating	Exhaust pressure	Main unit	
1	Pressure gage	Indicating	Inlet pressure	Main unit	
1	Pressure gage	Indicating	Steam pressure	Main unit	
1	Pressure gage	Indicating	Bearing-oil pressure	Main unit	
1	Pressure gage	Indicating	Relay-oil pressur	Main unit	
1	Vacuum gage	Mercurial	Condenser vacuum	Main unit	
1	Tachometer		Speed indicator	Main unit	Schuchardt & Schutte
1	Flow meter	G. E. Indicating	Steam from boilers	On boiler setting	General Electric Co.
1	Draft gage	Indicating	Boiler blast main	On boiler setting	Precision Instrument Co.
1	Draft gage	Inclined tube	Boiler firebox	Each boiler setting	Schaeffer & Budenberg
1	Draft gage	Indicating	Draft-economizer outlet	Induced draft fan room	Precision Instrument Co.
1	Thermometer	Recording	Gases from economizer	South end of boiler room	The Bristol Co.
1	Steam gage	Recording	Header steam pressure	Engineer's office	Schaeffer & Budenberg
1	Thermometer	Recording	Steam in header	Engineer's office	The Bristol Co.
1	Thermometer	Recording	Feed water to economizer	Engineer's office	The Bristol Co.
1	Thermometer	Recording	Feed water from economizer	Engineer's office	The Bristol Co.
1	Thermometer	Recording	Gases to economizer	Engineer's office	The Bristol Co.
1	CO_2 recorder	Simmance-Abady	Combustion record	Engineer's office	Precision Instrument Co.
1	Feed-water meter	Lea V-notch	Feed-water supply	Recorder in engineer's office	Yarnell-Waring Co.
1	Totalizing meter (electric)	Integrating and recording. Graphic recording, 3 circuits	Station load in megowatts	Engineer's Office	Westinghouse E. & M. Co.

Each auxiliary turbine for power and exciter service has a gage and tachometer similar to those for the main units.
The switchboard equipment comprises the usual integrating and indicating meters.

These readings show positive pressure at the top of the first pass, which is rather remarkable. At the same time the CO_2 in all the tests was over 15 per cent. and in only two did the oxygen run over 3 per cent.

Priming a Centrifugal Pump

By J. F. Jones

Centrifugal pumps, unless submerged, must be primed before they will operate. The experience of the writer with priming while in charge of an irrigation plant in the Gulf Coast regions of Texas may be interesting.

This plant lifts water from the San Jacinto River to a 300-ft. wooden flume, which discharges into a canal system watering several thousand acres of rice. The four centrifugal pumps used have rather long discharge pipes, Fig. 1. The pump shown is a 30-in. single-suction, 25,000-gal. per min. capacity pump and is rope-driven by a Greenwald compound condensing engine.

The discharge pipe is 67 ft. long, the upper end being closed by a flap-valve. For priming, a steam ejector was connected to a 2-in. hole on top of the pump casing. The ejector produced enough vacuum in the suction-pipe, pump and discharge pipe to fill the suction pipe and pump with water; then the engine would be started and brought up to speed.

This is the usual method of starting recommended by the pump builders. The length of the suction and discharge pipes caused many small air leaks, which condition was further aggravated by the difficulty of making the flap-valve seat air-tight. One night when shutting

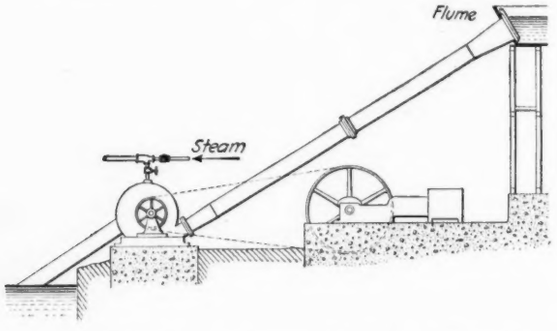


Fig. 1. Relative Locations of Pump, Engine and Flume

down there was a loud report and a stream of water came pouring down from the end of the flume. It was found that the upper end of the discharge pipe had collapsed for a distance of several feet and that the heavy cast-iron flange on its end was broken and torn loose from the flume.

The cause of the accident was plain. When the flap-valve on the end of the discharge pipe closed, the water ran down through the pump, forming a vacuum in the pipe, and the atmospheric pressure collapsed it. Just why a pipe calculated to resist an internal pressure of 150 lb. should fail under an external pressure of less than 15 lb. may not be apparent at a glance, but there was no disputing the fact. It was clearly time to make a change in the method of starting this pump.

First, the flap-valve was removed and a swinging gate was put in the flume several feet from the end of the discharge pipe which, being open to the air, could not be subject to a vacuum. Second, the ejector was taken off the top of the pump casing and connected to a 1¼-in. pipe-threaded hole drilled in the highest part of the suction elbow, Fig. 2. With this arrangement, the pump is started as follows:

First, it is necessary to have the lower end of the

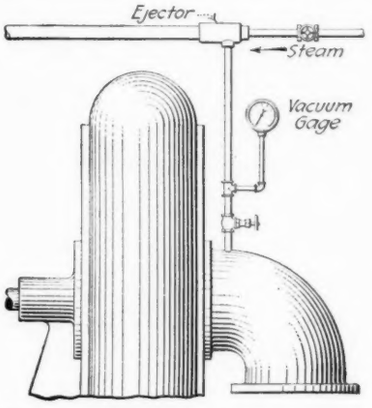


Fig. 2. How the Present Priming Ejector Is Connected

discharge pipe contain enough water to seal the discharge outlet of the pump casing. The leakage from the gate in the flume was usually ample for this purpose. Except when the water in the flume was low, it would be necessary to open the gate by hand to allow enough water to flow back into the discharge pipe.

Second, the throttle would be opened and the engine brought up to speed, as shown by the cutoff hooks beginning to trip by the action of the governor. When the ejector was started, and as the sealing water would be held in place by the revolving impeller, a vacuum was created in the suction pipe and in the pump sufficient to cause them to fill with water. When the pump "got the load," as shown by a slight decrease of speed, the throttle was opened.

As the ejector no longer had to exhaust the air from the 67 ft. of discharge pipe, the time required to start the pump was shortened, usually taking only four or five minutes for priming. A vacuum gage on the suction side of the ejector was found desirable.

Simplified Formulas—Two rules or formulas for finding the capacity of tanks in U. S. gallons and for finding the heating surfaces of boiler tubes are given below, which are easily worked out by simple multiplication, no division being necessary:

Rule—To find the capacity of a cylindrical tank in U. S. gallons, square the diameter in inches, multiply by the length or height in inches and multiply the product by the constant 0.0034.

Formula, $D^2 \times H \times 0.0034 =$ capacity

Proof, $0.7854 \div 231 = 0.0034$ the constant

Rule—To find the heating surface of boiler tubes, multiply the diameter of the tubes in inches by their length in feet and that product by the constant 0.2618.

Formula, $D \times L \times 0.2618 =$ heating surface

Proof, 3.1416 cir. ÷ 12 in. = 0.2618

The Eighth Annual Report of the District Police of the State of Massachusetts, for the year ending Oct. 31, 1914, regarding the examination and licensing of stationary engineers, contains the following: The number of applicants examined for licenses as engineers or firemen was 6490, of which 2955 were granted licenses and 3535 were rejected; for operators of hoisting machinery 147 were examined, 125 passed and 22 were rejected; grand total of applications, 6637; number licenses, 3080; rejected, 3557.

Just for Fun

[More "original ideas" sent in by readers in response to our request in the Jan. 19 issue for stories of amusing stupidity.—EDITOR.]

In a certain power plant which the writer visits occasionally, there is a recording boiler feed-water meter. Some six months ago the nozzle became so stopped up with the sediment in the feed water that the records were worthless. Nevertheless, the engineer religiously changes the charts every day and reads the integrating dial, in spite of the fact that he knows the nozzle is plugged up.—*Loren L. Hebberd, Milwaukee, Wis.*

The following piece of rank stupidity is reported "just for fun." We purchased a forced-draft system for a boiler, which was a miserable failure. When the writer told the representative of the company the facts of the case he hauled out his data sheet and started to take down the data which were given him. He finally asked what kind of coal we burned, and when told it was pea coal he immediately said: "That's the reason it would not work. This blower is so delicately adjusted and carefully designed for buckwheat coal that it could not be expected to work on pea coal."—*T. Newbury, Monroe, N. Y.*

A 10-kw. dynamo was used to light the mill, and short-circuits were common. One night a short came on that nearly threw the belt. I looked the main mill over, but failed to find it. In a short time it came on again, and I finally asked some of the men if they had done anything to the wiring. One of them said he had put an extension on a certain light, but had insulated it so that he knew it was all right.

He had found a couple of pieces of bare No. 12 wire, also a long piece of rubber tube. He twisted the wires together, put them in the rubber tube, attached the socket to one end, and hooked the other ends on the circuit wires. He said he didn't see how there could be trouble, when they were covered with the rubber tube.—*V. C. Wood, Copenhagen, N. Y.*

"Last week," said a friend of mine, "I was called to inspect an engine installation that our firm had sold. Complaint had been made that neither the pump nor the injector that came with the outfit would work. We had sold engines and boilers equipped with pumps and injectors of this particular kind for many years and never received any complaints about them. I was rather curious and somewhat perplexed as to what the trouble could be.

"When I arrived at the plant and the steam pressure was brought up to normal, I attached one end of a hose to the suction side of the feed pump and put the other into a pail of water. The first stroke of the pump emptied the pail. Then, with a barrel of water I tested out the pump and injector and both worked perfectly. There was only one conclusion to arrive at, and to the accompaniment of a few choice remarks the cover over the well used as a source of water-supply was removed and revealed the trouble—the well was dry.

"The manager was told that the cost of the lesson that neither pump nor injector could create water would be an even $50."—*C. E. Anderson, Chicago, Ill.*

Mixed-Pressure Turbine and Condenser Outfit

The Columbia Plate Glass Co., Blairsville, Penn., has recognized that the utilization of exhaust steam for the generation of power would effect a desirable saving in coal costs and help the production by giving better facilities for output. Accordingly, a 300-kw. mixed-pressure Kerr steam turbine was purchased, Fig. 1. It is a 450-hp. capacity, seven-stage, impulse-type unit connected through reduction gears to a 600-r.p.m., direct-current generator. The exhaust steam from several Corliss engines is piped to the turbine and ordinarily enough steam is obtained from this source, at a pressure of about one pound above atmosphere, to generate all of the electricity required in the plant. Whenever the Corliss engines are shut down, live steam is admitted automatically through expanding nozzles.

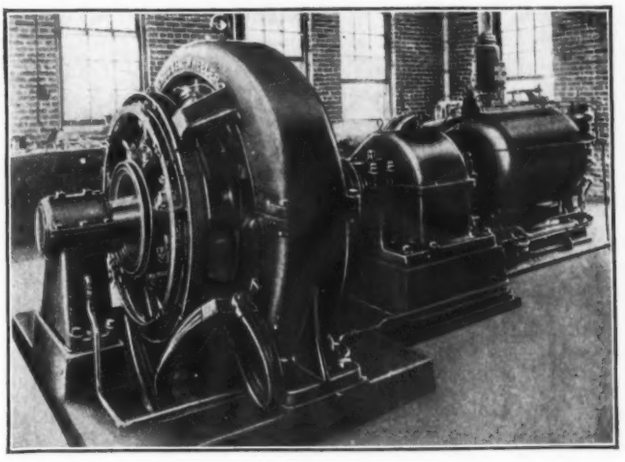


FIG. 1. THE MIXED-PRESSURE TURBINE UNIT

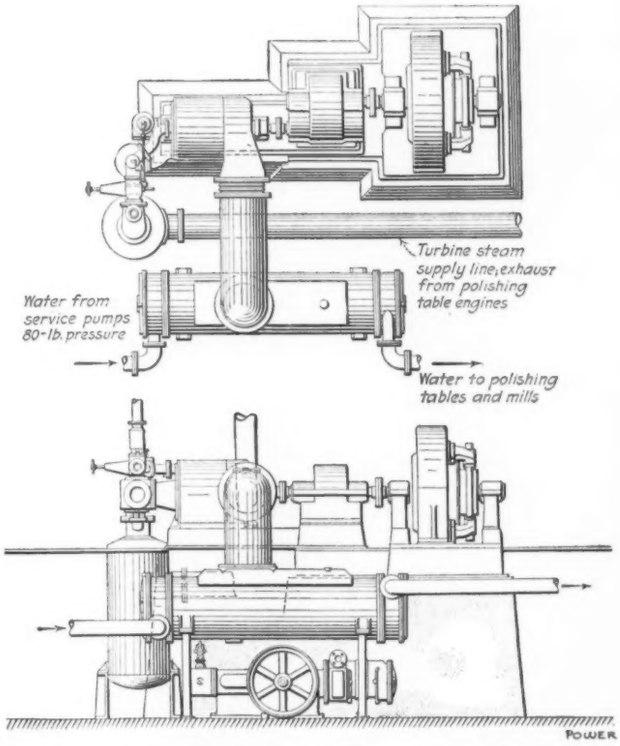

Turbine steam supply line, exhaust from polishing table engines
Water from service pumps 80-lb. pressure
Water to polishing tables and mills
POWER

FIG. 2. ARRANGEMENT OF THE TURBINE AND CONDENSER

The turbine exhausts into a surface condenser of the water-works type—that is, it is installed in the water-supply line to the mills, Fig. 2, and this water produces the cooling effect necessary for a vacuum of 28 in. on its way to the grinding tables. This feature of the installation eliminates any pumping of water for the condenser and makes use of the water which is being pumped. The condenser is designed for a water pressure of 80 lb., the pressure carried in the mill lines.

The turbine is placed beside two engine-driven generator sets which have operated continuously on high-pressure steam for years. It is estimated that these machines used about $20 worth of coal per day, so that the saving effected by the exhaust turbine is about $6000 per year, or enough to cover the cost of the machine in a period of two years. The turbine operates continuously twenty-four hours a day, six days a week.

Oil under 6 lb. pressure is pumped to the bearing, and then flows by gravity to an oil reservoir in the bedplate; there it is strained and cooled. A small steam turbine-driven centrifugal pump is bolted on this bedplate and used for starting the oiling system before the turbine is started.

Strength of Diagonal Joints

By J. E. Terman

Nearly all authorities on boiler construction have advocated the use of diagonal seams for boiler patches of small size. Hence, the common use of the horseshoe and diamond shapes, where bags or similar defects in the vicinity of girth seams have made the removal of a part of the shell plate necessary. The writer has long been an advocate of such a method of repair and does not now wish to be understood as having changed.

However, analyzing diagonal boiler joints in the light of what is known of the strength of riveted joints, it appears possible that there may be an error in assuming that such angular joints, unless occupying a position of angularity of 45 deg. or more with a line parallel to the axis of the boiler, are superior in strength to joints of the same design placed on lines parallel to the axis of the boiler.

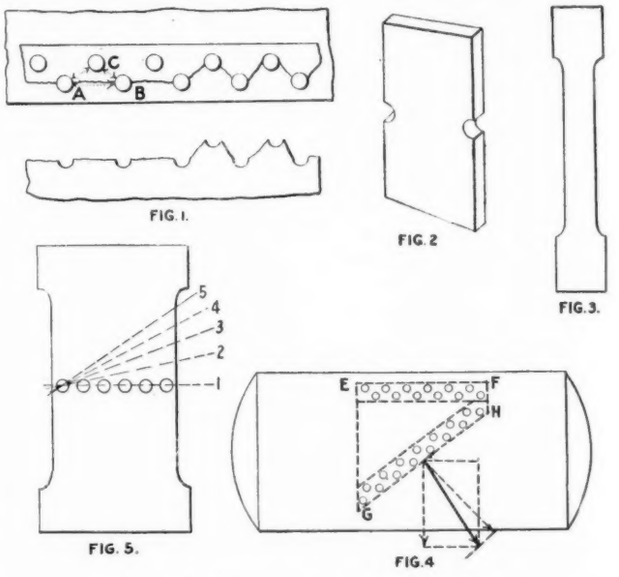
It was determined by experiments on riveted joints made many years ago, that in order to insure the breaking of the net section of a double-riveted joint as illustrated in Fig. 1, the combined net section of the metal from *A* to *C* and *C* to *B* would have to be about 30 to 35 per cent. greater than from *A* to *B*. With less metal on the diagonals than indicated, the break would be liable to occur, as illustrated on the right-hand side of Fig. 1, at the last space between rivets.

There are probably two reasons for the diminution of strength in the angular section, the first being that the material is not subjected to true tensile stress, but is partly in shear and is weaker to resist a stress of this character; the second reason is, the material can draw down more readily in the inclined sections than in the longitudinal. The latter reason is based on the effect noted in testing materials, where, if a sample of plate is tested in the shape which was formerly used by the U. S. Government and illustrated in Fig. 2, the tested tensile strength would be about 10,000 lb. higher than if tested in the form shown in Fig. 3, which is the standard, because the area of metal at the time of failure is greater than would be the case with the same-sized test specimen arranged in the form illustrated in Fig. 3.

This increase of area is due to the reinforcing effect of the additional metal (Fig. 2) close to the ruptured section, the radii of the semicircles on the side of the test specimen being only one-half inch.

Rivet holes in a plate produce the same effect on the apparent strength of the net section of metal between the holes as is produced by the semicircles in Fig. 2, and this effect is maximum when the line of holes is at right angles to the direction of applied stress and diminishes as the angle between the line of holes and the direction of applied stress decreases.

It is, of course, true, as can be demonstrated by calculation, that the stresses in a cylinder due to internal pressure and at right angles to the direction of an angular joint such as *GH*, Fig. 4, is less per unit length of joint than if the joint occupied a position parallel with the axis of the cylinder, as *EF*. However, the girth-wise stress is the same in all parts of a cylinder, and unless the angle between *EF* and *GH* is such that the net section of metal from *G* to *H* is 30 per cent. or more in excess of the net section of metal from *E* to *F*, then failure along *GH* may be expected, if the test results for the strength of angular net sections in riveted joints hold good in such a case.



Proposed Tests for Diagonal Seams

It appears that no tests have been made to determine the effect on its strength of varying the angle of a joint with respect to the direction of the applied stress. However, it may be inferred from the behavior of the angular sections between rivet holes in tests made on riveted joints located at right angles to the applied stress, that if a series of test specimens were prepared as illustrated in Fig. 5, the rivet holes being drilled the same distance apart for each specimen, but the line of holes occupying a different angle on each specimen, as No. 1, No. 2, No. 3, etc., indicated in Fig. 5, the breaking strength of the different specimens would probably not vary greatly. If such tests were conducted using a sufficiently wide range of angles, they would demonstrate in a measure if the angularity of a joint as commonly used in making repairs is a real factor in determining its strength. It

might be argued that in such a test the actual conditions with respect to the stresses applied to a joint on a cylinder subjected to internal pressure would not be reproduced, because in the latter case there would be longitudinal stresses produced by the pressure acting on the heads of the cylinder. However, by including such longitudinal stresses the joint could hardly be expected to show greater strength than when considered without taking them into account. Also, in the horizontal-tubular type of boiler, it is possible that the longitudinal stresses in the shell along the bottom of the boiler are a negligible quantity. After all is said and done in the matter of estimating the strength of short boiler seams as used for patches, we cannot hope to have come very close to the true facts in the case, because the distribution of the stresses in the shell or patch, due to difference in the fitting of the patch and fit of rivets in the holes, would be likely to materially change the results in every case.

The intent of this article, as stated at the beginning, is not to discourage the use of diagonal boiler joints for patches, but to show that by the usual methods of calculating the strength of such joints there is a possibility that some of the most important factors entering the problem have been neglected. It is also probable that considerable changes in the angularity of such joints may produce relatively slight changes in their strength.

The determination of the facts, as regards the effect on the strength of a test specimen when pierced by rows of rivet holes equally spaced, but occupying various angles with respect to the line of direction of stress, as illustrated in Fig. 5, would be an experiment easily performed by anyone having the facilities to make tensile tests on large specimens, and the results would be of great interest to all engaged in boiler design and construction.

Firebrick for Boiler Furnaces

By A. D. Williams

Modern large combustion chambers with high boiler settings result in much higher furnace temperatures than are reached in those settings where the cold tubes are close to the coal bed. These high temperatures mean that the materials for furnace construction must have a higher refractory resistance to meet the demands of the service. The grades of firebrick which proved everything to be desired with the old-style setting may not be at all satisfactory with furnaces of large volume. The chemical composition of a brick and its fusion temperature are not reliable indications of its refractoriness in service, for structural differences have an effect upon wearing qualities.

Gilbert Rigg* gave the following properties to be possessed by a product which is to be used as a refractory:

1. Absolute infusibility at the highest working temperatures.
2. Complete absence of deformation and shrinking under working conditions.
3. Mechanical strength.
4. Complete resistance to the penetration of vapors, slags, etc.
5. A chemical composition fitted to withstand as completely as possible the corrosive action of the substances to which the bricks are exposed.
6. Equality and fixity of form and dimensions.

*See "Metallurgical and Chemical Engineer" for May, 1910.

The writer would add two more properties as being desirable, although some might, perhaps, consider them covered by the properties specified by Mr. Rigg. They are:

7. Resistance to erosion.
8. The ability to withstand sudden temperature changes without frittering or spalling off.

Technological paper No. 10 of the Bureau of Standards gives the melting points of various bricks as follows:

Kind of Brick	Melting Point, Degrees C.	Melting Point, Degrees F.	Chemical Nature
Fireclay	1555-1725	2863-3169	Neutral or acid
Bauxite	1565-1785	2881-3277	Basic or neutral
Silica	1700-1705	3092-3101	Acid
Chromite	2050	3754	Neutral
Magnesia	2165	3993	Basic

Iron, silica, alumina, lime and sulphur are the clinker-forming elements of coal. The degree of fusibility of the clinker varies directly as the percentages of sulphur, iron and lime and inversely as the percentages of silica and alumina.* The tendency of the iron to combine with silica in the coal and ash and form a slag is well known. and a cinder of this kind will have a strong affinity for the silica in the brickwork. This is one of the reasons that silica and fireclay brick have a strong tendency to disintegrate at high temperatures along the side of the furnace. Cinder in cooler furnaces sticks to the brickwork, which is often damaged in the attempts made to bar the clinker loose. With certain kinds of cinder it is possible to feed a small quantity of limestone and melt a pasty slag free from the side walls. Fluorspar has a similar effect upon some cinder. Both of these remedies should be used with discretion and care to avoid fluxing the cinder to such an extent that it will flow down on the grate bars and chill there, in which case it will be more troublesome than in its original consistency.

There is no reason why silica brick should not be used above the cinder line, for the upper parts of the walls and for coking arches, where they are exposed to the action of the flame only. Silica brick are used in this manner in basic openhearth furnaces and have proved durable.

Bauxite brick have been tried to some extent for the side walls of the firebox. These brick cost from two to three times as much as silica or high-grade fireclay brick. They are very hard and tough, the cinder does not stick to them and they last considerably longer than silica brick where exposed to the action of the slag. They have one serious disadvantage—a tendency to spall or fritter off if suddenly chilled. In a firebox this is often troublesome. The barring doors for the fires are generally located close to the side walls, and whenever these doors are opened a blast of cold air will be drawn in along the walls unless the draft can be so well balanced that the furnace is slightly above or at the same pressure as the atmosphere. When the furnace is below the atmospheric pressure this chilling draft results in rapid spalling close to the door and it may be necessary to shut the boiler down to patch this portion of the lining long before the rest of the fire requires repairs. Bauxite brick, even with this disadvantage, have proven quite durable, lasting from three to eight times as long as the cheaper brick. Although bauxite is extremely refractory, it must be almost completely calcined, otherwise it will shrink excessively at furnace temperatures. These brick must be burned in an oxidizing atmosphere, otherwise the iron compounds in the

*That sulphur causes clinkering is not generally agreed. The belief that it has no appreciable influence on clinkering is on the increase.—EDITOR.

bauxite will be reduced and the brick will have a low heat resistance. Bauxite brick are frequently considered as basic, though in many ways they partake of a neutral character. Bauxite is mined extensively as an ore of aluminum. The average composition of that from Georgia is:

Silica (SiO_2)	3.00 per cent.
Iron peroxide (Fe_2O_3)	1.50 per cent.
Alumina (Al_2O_3)	58.67 per cent.
Water (H_2O)	32.33 per cent.
Titanium (TiO_2)	4.50 per cent.

Another material used in making refractories which may possess some possibilities of assisting in building durable fireboxes is chrome iron ore or chromite. These brick cost more than twice as much as bauxite brick, but are neutral in character. This material is infusible and it is difficult to sinter it thoroughly, and unless thoroughly sintered it does not stand erosion.

TYPICAL ANALYSIS OF CHROMITE

Sesquioxide of chromium (Cr_2O_3)	35-50 per cent.
Alumina (Al_2O_3)	16-28 per cent.
Iron peroxide (Fe_2O_3)	17 per cent.
Silica (SiO_2)	4- 8 per cent.
Magnesia (MgO)	10-17 per cent.
Lime (CaO)	1- 2 per cent.

Chrome brick are well adapted to resist extremely high temperatures, though chrome iron ore is variable in composition.

Changing the Service of Direct-Current Machines

By Gordon Fox

SYNOPSIS—Directions for changing over a motor into a generator, and vice versa; also a discussion of the relative characteristics when operated under these conditions.

Occasions often arise making it desirable to utilize a direct-current motor as a generator, or *vice versa*. Most direct-current motors and generators are very much alike; the armatures and commutators are identical, the brushes are the same except as to setting, and the fields are similar. That the machines are interchangeable is shown by the fact that if two direct-current generators, *A* and *B*, are operated in parallel (driven from separate sources) and the engine driving *A* be shut down, its generator will run as a motor and draw current from generator *B*.

A motor is, in reality, a "counter electromotive-force generator." The armature rotating within the field poles generates a voltage less than the impressed voltage by an amount sufficient to allow the load current to flow. As the load increases the motor speed decreases, the counter electromotive force decreases and the current increases. A 230-volt compound-wound motor may have a counter electromotive force of perhaps 225 volts at no load and 215 volts at full load, the decrease being due partly to the drop in speed. Consider that the no-load speed of this motor is 900 r.p.m. and its full-load speed 850 r.p.m. If, instead of driving a mechanical load, the machine were driven at a speed of about 950 r.p.m. it would act as a generator, tending to generate more than 230 volts and pumping current out into the line. The armature IR drop must be subtracted from the line voltage to obtain the counter electromotive force of a motor but must be added to the line voltage to determine the generated electromotive force of a generator. Therefore, as a generator a machine must run faster than as a motor to operate at the same line voltage.

As a generator it is further desirable to have a little leeway for the use of the field rheostat. This necessitates a greater increase in speed to compensate for the slightly weakened field. Moreover, generator voltages are usually higher than motor voltages upon the same system because of the line drop. In general it may be stated that a motor must be driven about 10 per cent. above its speed rating in order to deliver rated voltage as a generator. Conversely, a generator used as a motor upon rated voltage will rotate about 10 per cent. below the speed indicated on its name-plate. These figures are at best only approximate, due to the wide range of characteristics of different designs.

In connecting a compound-wound motor for use as a generator the only change ordinarily required is the reversal of the series field connections. If this is not done the series field will buck the shunt field and the voltage regulation will be very poor. If the direction of rotation as a motor be unchanged, the machine will build up as a generator. If the rotation as a generator be opposite to that as a motor, then it becomes necessary to reverse the armature terminals in order to enable the generator to build up. If this is not done, the voltage generated in the armature through the action of the residual magnetism will cause the field coils to buck the residual effect rather than to aid it.

The external connections of a generator differ from those of a motor, in that the generator requires no starting resistance in series with the armature, but is provided with a rheostat in the shunt field circuit.

If a shunt motor be used as a generator it will not deliver a very satisfactory voltage. The purpose of the compound winding of a generator is to maintain the voltage or to cause it to increase under load. A shunt machine will drop in voltage from 5 to 15 per cent., under load, depending upon the design. The voltage can, of course, be regulated by manual control of the field rheostat. A compound-wound motor should be selected if possible where automatic voltage regulation is desirable. Standard motors are built for 20 per cent. to 40 per cent. compounding effect; that is, the series ampere-turns at full load are 20 to 40 per cent. of the shunt ampere-turns at rated voltage. The majority of over-compounded generators are designed for a voltage increase of about 10 per cent. under full load. This requires perhaps 20 per cent. series ampere-turns at full load, since generators are ordinarily operated above the knee of the saturation curve where the series ampere-turns are proportionately less effective. Therefore, a motor having 20 per cent. compounding is usually well adapted to run as a motor.

Since it is desirable to have some rheostat leeway for controlling the voltage, the shunt field will usually be

worked at a lower density as a generator than as a motor, the deficiency in magnetic strength being compensated by increased speed. A low density at no load means that the compounding ampere-turns have greater effect. It will usually be found that a compound-wound motor adapted for generator service has an excess of compounding. This is a good fault inasmuch as it is an easy matter to shunt the series winding with german silver resistance and thus adjust its value as desired.

The full-load neutral, or best running, brush position for a motor is at a point shifted from the no-load neutral in a direction against that of rotation. In a generator the neutral shifts with the direction of rotation as the load is imposed. Consequently, if a machine be operated first as a motor and then as a generator, the rotation being unchanged, it is necessary to shift the brushes a considerable distance in a direction with the rotation. On the other hand, if the rotation be reversed, the original motor shift against the direction of rotation now becomes a generator shift with the rotation, and further change will likely be unnecessary. However, if, due to increased speed, the machine operates as a generator upon a weaker field than it had been running as a motor, the armature reactions will have an increased effect and a greater shift may be required.

An interpole motor is well adapted for use as a generator. If a compound motor is not available the interpole motor is its best substitute, since the action of the interpoles can be utilized to some extent in securing the voltage regulation desired. The interpoles of a motor have the same polarity as the main poles preceding them in a direction against the rotation. The interpoles of a generator have the opposite relation, being of the same polarity as the main poles following, in a direction with the rotation. When an interpole motor is changed over into a generator the relative polarity of the armature and the interpole must be reversed. One armature terminal is usually connected permanently to one interpole terminal. In making the change it is necessary to reverse this connection, using the other interpole terminal and the same armature terminal.

One cause of the dropping off in voltage of a shunt generator under load lies in the armature reaction. Since the interpole neutralizes armature reaction, it tends to thus better the voltage regulation. The regulation of an interpole generator can be further improved by giving the brushes a slight shift off neutral in a direction against the rotation. This procedure is in a way similar to shifting the series winding of the interpole over to the following main pole. The magnetizing effect of the interpole assists the main poles, increases their magnetism under load and, therefore, tends to maintain the load voltage and to improve the regulation.

It is obvious that the procedure for changing a generator into a motor is the exact reverse of that for changing a motor into a generator.

When the Gas Engine Will Not Start

By E. N. Percy

SYNOPSIS—Directions for systematically following up the trouble when an engine refuses to start; and, after having located the trouble, suggestions for remedying it.

When a gas engine refuses to start, there is usually one of two things wrong—the mixture or the ignition. It is best to test out the ignition first because it is easy to determine definitely if the trouble is from this source. First, test the battery by short-circuiting it with a piece of wire and note if a fat spark is obtained when the wire is snapped across the terminals. All engines with electric ignition have a timing commutator, regardless of the system used. Therefore, turn over the engine to a firing point, and if high-tension ignition is used the buzzer on the coil should sound. If it does not, it is probably out of adjustment or the spark-plug points need going over with a fine file or piece of emery paper. The adjusting screw should then be turned carefully back and forth until the buzzer begins to sound.

After the buzzer is working, place a screw-driver on the cylinder head and tip it until within about $\frac{1}{16}$ in. of the spark plug. If no spark jumps across from the top of the plug to the screw-driver, the indications are that either the plug is foul and the points short-circuited, the connection is broken, or the high-tension cables are leaking sparks onto the frame somewhere. The farther the spark jumps the stronger the battery.

One of the most baffling troubles is a weak battery. This may comply with the usual tests without giving indications of troubles, yet the spark will not be hot enough to ignite the mixture in a cold engine, although it may have been working well when the engine was shut down. For this reason, it is wise to use batteries only for starting, after which a generator or a magneto should be switched on.

Engines having make-and-break ignition should be tested in the same way, so far as the timer is concerned, but there is no buzzer. Instead, a screw-driver or piece of wire is snapped across the wire connection on the make-and-break plug, the other end of the wire being in contact with the engine cylinder. If a fat spark is had in this way, the igniter may be removed and snapped by hand, to see if it sparks. The wire should then be connected, and the ground side of the igniter should touch the iron of the cylinder. Care should be taken that the mixture in the cylinder is not ignited, or the operator may get burned. The make-and-break plug may now be returned to the cylinder and the adjustment examined. In this connection it should be remembered that the spark is made when the electrodes separate—not when they come together—and the quicker they separate, the better will be the spark. For this reason, slow-speed engines must have a snap-off mechanism for a make-and-break spark, while a high-speed engine can get a good spark from an igniter connected directly to a cam rod, without a snap-off mechanism.

Having determined that the trouble is not with the ignition, or having fixed such trouble as may exist, and still not being able to start the engine, it becomes necessary to investigate the mixture. If the engine is operat-

ing on gas of any kind, there is an excellent method of getting the right mixture into the cylinder. Let the air and gas be set as nearly correct as possible under the circumstances; then draw in a charge by turning over the engine by hand, and compress it slightly. Open a cylinder pet-cock slightly and apply a match. If the flame is smoky, there is too much gas in the mixture; if it is hard to light, there is not enough gas, particularly if the flame is colorless. If the flame is a clear blue or silver, the mixture is about right and should ignite. In fact, it may ignite by striking back into the cylinder through the pet-cock, but no harm will be done, except to move the piston slightly. If there is much compression the mixture may blow out of the pet-cock so hard that it will be difficult to light it.

With carbureting engines, this same plan is successful, but is attended with risk of fire, because of the tendency of liquid fuels to collect around the engine, their vapors greatly increasing the risk. In this type of engine trouble may be expected in starting in cold weather. To make certain of starting easily, fill the jackets with boiling water, if possible, and prime each cylinder with one squirt of gasoline, and fill the inlet pipes with air saturated with gasoline. If the engine still refuses to start, take out the spark plugs and drop a lighted match into the cylinder, first making sure that there is nothing in the vicinity to take fire. The cold gasoline in the cylinder will explode and rush out of the spark-plug hole with a roar, and the operator must be careful not to get too close. This is practically the only remedy for a flooded cylinder, except to laboriously turn over the engine until it is dried out.

Many of the cheaper engines have no carburetors, but merely a valve which lets the fuel into the inlet pipe, and some rough device for controlling the air. They frequently give trouble in starting, no matter how familiar the operator becomes with them. The best way to start such an engine is to have the fuel shut off, prime the cylinder, and squirt fuel over the inside of the inlet pipe. The engine will then start, and run for several revolutions, during which the fuel valve may be opened until the operation is regular. The reason for this is that this type of fuel valve usually floods the engine when starting, and a flooded cylinder is decidedly troublesome.

Unless an engine is badly flooded, it will start on most any kind of a mixture, but will not run long, nor will it develop much power unless the mixture is just right. Find out first where the adjustments are, then start the engine by priming, and after it is going, feed it with the squirt can with one hand and adjust the carburetor with the other, until it is fairly under way. Then, when under load, make the adjustments that seem to do the work best. If black smoke is given off, the mixture is too rich. This should not be confused with blue smoke which comes only from an excess of lubricating oil. There is usually a small excess of oil in the crank case when the engine is first started, and for this reason the supply of lubricant should not be cut down unless the smoke continues for some time. When the engine misses, and "coughs" back into the carburetor or inlet pipes, the mixture is too lean, and more fuel is required. The greatest economy is secured by using the thinnest mixture that will carry the load reliably. Mixtures rich enough to smoke are weak, not strong. The strongest mixture has been found to be that which contains a little more air than necessary to properly burn the fuel.

There are some two-stroke-cycle engines, mostly small, that are perfect mules of obstinacy when being started. The reason is that after the fuel is carbureted it does not go into the cylinder at high velocity, as in a four-stroke-cycle type, but is first detained in a cold crank case, where the fuel condenses, and air or a very lean mixture goes to the cylinder. Also, many of these engines have gauze in the inlet port to prevent backfiring into the crank case. This gauze, when cold, condenses much of the fuel, and it becomes necessary to prime the cylinders in starting, but it is equally important to refrain from flooding them. A good method is to draw off all the lubricating oil from the crank case and replace it with oil which has been heated until it smokes. This will usually heat the engine enough to start easily, as the cylinder does not have to be particularly hot if the crank case is hot enough to keep it from condensing the fuel.

In starting a cold engine, it pays to take the trouble to heat it up by one of the methods suggested, for after such treatment it starts so easily, provided the ignition is all right, that the uselessness of tugging and straining is apparent. The writer has seen engines of 40 or 50 hp. started by pouring a tea-kettle of hot water into the jacket of one cylinder. Those that give the most trouble are of the cheap factory type, without adequate carburetors or reliable ignition, yet they are used extensively in contracting work, agricultural machinery, and general small power work. The gas or gasoline engine is just as reliable as the steam engine, provided it is made equally well and receives equal attention and study.

There are now many devices and systems for making these engines self-starting. These systems, as a rule, are reliable, but a man must know his engine just the same, and be able to know that it is in condition to start, before he risks using up the power stored by the self-starter for that purpose.

Comparative Tests of Stoker- and Hand-Fired Boilers

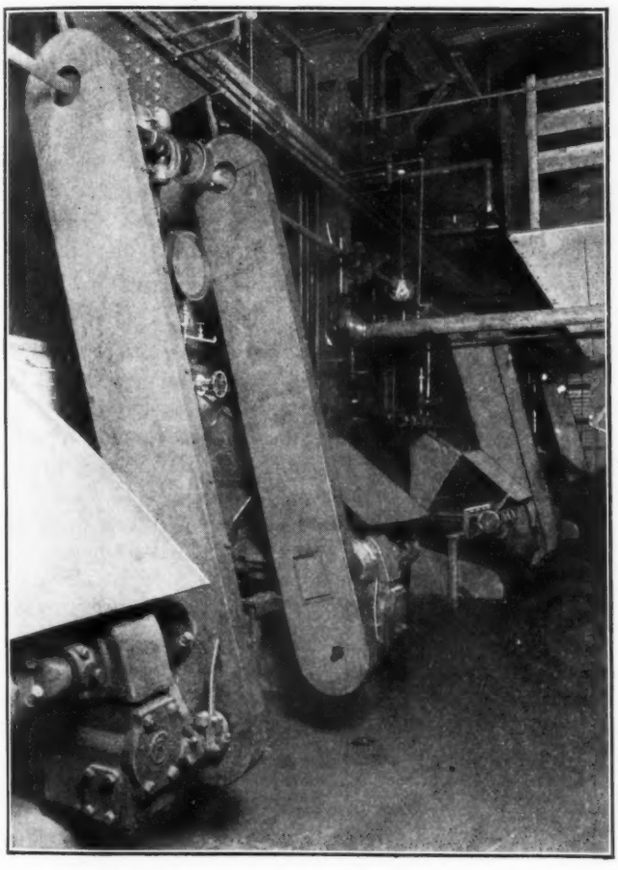
By H. S. Knowlton

Through the courtesy of the engineering department of the Norton Co., Worcester, Mass., the following test data are given, showing the comparative efficiency of hand and stoker firing in the boiler plant of this concern at Barbers Crossing. This plant was recently equipped with self-dumping, underfeed stokers, which are comparatively new in the field of power-plant equipment. The figures given are among the first to be published upon their operation. Their most striking features are: In place of stationary dead plates are moving, air-supplying grates, carried by the reciprocating sides of the retorts; moving overfeed grates extending across the entire width of the stoker, and pusher noses with ash-supporting plates for continuously dumping the refuse. This is the only type of underfeed stoker having live grate surfaces and the continuous automatic dumping of refuse.

As shown in the illustration, the Norton installation consists of a set of three-retort units per boiler, the steam-generating equipment of the plant having five 300-hp. vertical fire-tube boilers. The stokers are chain-driven from a fan shaft carried along the boiler fronts, the fan being located in the engine room to enable it to be under the eye of the engineer, besides furnishing a means

of exhausting air from the engine room and aiding in the ventilation. The fan is 5 ft. 6 in. diameter, with three-quarter housing, and is driven by a 7x6-in. vertical inclosed engine, the maximum speed being 450 r.p.m. The fan discharge to the stoker air chambers is through a concrete duct in the floor with a maximum cross-sectional area of 1720 sq.in., each stoker being supplied through an 18x18-in. branch duct, while the cross-section of the main duct is diminished accordingly at each boiler. The fan speed is automatically controlled by the boiler pressure.

The boilers are fed with water by a centrifugal pump with a capacity of 90 gal. per minute, the pump being direct-connected to a 20-hp., 440-volt induction motor running 3600 r.p.m. This is about the smallest size of



VIEW OF BOILER ROOM OF NORTON CO.'S PLANT

centrifugal feed pump capable of being operated at good efficiency, in view of the limitations of water passages. It is estimated that the steam consumption of the boiler-feed equipment of the plant has been cut in half by the installation of the motor-driven pump.

A fuel bed about 2 ft. thick is maintained on the grates, and above each set of retorts is a hopper containing 750 lb. of coal.

At a coal cost of about $4 per ton, the equipment of the five boilers of the plant will pay for itself in about two years.

In analyzing the tests the Norton company points out that they represent an average taken from daily practice. While the hand firing is not all it should have been, the stoker eliminates all chance of carelessness likely to arise in a plant of moderate capacity not equipped with recording instruments maintaining a constant check on the fireman. The company has had but one stoker in operation continuously for about a year, and in that time has had no expense for repairs. The design of the working parts seems well balanced, as no weakness has so far developed. The capacity of the stokers has not as yet had to be tested, but the company is of the opinion that, if necessary,

TEST DATA

Boiler No.	1	3
Type of firing	Stoker	Hand
Date	May 14, 1914	June 16, 1914
Time	7 a.m. - 6 p.m.	7 a.m. - 6 p.m.
Duration	10 hr.	10 hr.
Average temperature feed water	179 deg.	157 deg.
Average gage pressure	142 lb.	142 lb
Coal burned	8690 lb.	8470 lb.
Ash	720 lb.	700 lb.
Per cent. ash by weight	8	9
Water fed	97,200 lb.	80,774 lb.
Quality steam, assumed	Dry	Dry
Water evaporated per lb. coal fired	11.2 lb.	9.53 lb.
Equivalent evaporation per lb. coal	12.2 lb.	10.57 lb.
Per cent. CO_2	10.8	7.6
Per cent. CO	0.3	0.3
Heating surface	3444 sq.ft.	3324 sq.ft.
Grate surface	35 sq.ft.	42 sq.ft.
Evaporation per sq.ft. heating surface per hr.	2.8 lb.	2.4 lb.
Evaporation per sq.ft. grate surface per hr.	277 lb.	192 lb.
Coal burned per sq.ft. grate surface per hr.	25 lb.	20 lb.
Flue temperature	401 deg. F.	473 deg. F.
Per cent. combustible in ash	12.42	Not determined
B.t.u. per lb. coal as fired	14,600	14,600
Relative efficiency, per cent	81	70

EQUIPMENT IN CONNECTION WITH TEST

Equipment	Manufacturer
Boilers, "Manning"	D. M. Dillon Steam Boiler Works
Stoker, "Riley"	Sanford Riley Stoker Co., Ltd.
Centrifugal feed pump	De Laval Steam Turbine Co.
Draft fans	B. F. Sturtevant Co.

it could push the boilers much beyond their rating. It is now doing with three boilers what formerly required four. This is due to the ease with which the boilers can be maintained at full rating and better efficiency. When the coal-hopper installation is complete, with facilities for overhead gravity delivery of fuel, it is expected that one fireman will handle five boilers, whereas under the old methods of hand firing two men were required.

The Storage Battery is composed of three fundamental working elements, namely, the positive plate, the negative plate and the electrolyte. There are several processes used in the manufacture of the plates, but the one most generally employed consists in making the positive elements of lead peroxide (PbO_2) and the negative of sponge lead (Pb). The electrolyte consists of sulphuric acid (H_2SO_4) diluted with water (H_2O). The active materials are held in their respective positions by lead grids.

There are various theories in regard to the chemical reactions which take place in a storage cell, but the one most generally accepted is that the passage of the current upon discharge causes the acid to react upon the active materials of the plates, forming in their places lead sulphate ($PbSO_4$), the reaction being accompanied by a reduction of part of the acid and the formation of water in its place. This is the cause of the decrease in the density of the electrolyte observed upon discharge. The chemical formula expressing the reaction at the positive plate upon discharge is

Lead Peroxide		Sulphuric Acid		Lead Sulphate		Water		Oxygen
PbO_2	+	H_2SO_4	=	$PbSO_4$	+	H_2O	+	O

That of the negative plate is

Sponge Lead		Sulphuric Acid		Lead Sulphate		Hydrogen
Pb	+	H_2SO_4	=	$PbSO_4$	+	H_2

Upon charging, the current is passed through the battery in the direction opposite to that of discharge, with the result that the reactions expressed in the foregoing equations are reversed. The lead sulphate is reduced, the active materials —lead peroxide and sponge lead—are restored to their respective plates and the acid taken from the electrolyte on discharge returns to it, the water previously formed disappearing. This replenishment of the electrolyte causes the rise in density observed upon charging.

Forty Years' Advance in Steam Power Units

SYNOPSIS—Comments on the accompanying graphical comparison of the Centennial Corliss engine with a turbine of the same power, showing its relative size, and a turbine of the same size, giving its relative power.

In the account given of the Panama-Pacific Exposition in last week's issue reference was made to the big Corliss engine which was a feature of the Centennial Exposition at Philadelphia in 1876. This was in connection with an outline of the advance which has been made in steam prime movers since that day. The accompanying page illustration shows this progress of forty years graphically and gives briefly some of the more important data respecting the three units shown. The story is not complete in that it leaves out the chain of steps in the evolution, but it was not the purpose to portray this. Rather was it the intention to contrast and compare the old Centennial engine with the turbine form of prime mover, which is generally adopted today where large power capacities are desired in the space allotted.

Directly beneath the Corliss engine is shown a turbine of equivalent power, reproduced to the same scale in order to compare the relative sizes of the two machines. In other words, they are shown as the two machines would actually appear when viewed at the same distance from the observer. At the bottom of the page is shown, also to the same scale, another turbine, the largest at present in operation. The comparison of spaces required by the three units is unfair to the turbines in that they are complete electric generating units, whereas the Corliss engine shows only the steam end, its output being purely mechanical energy—for direct-connected steam-electric units were unknown at that time.

In the article of last week mention was made of the manner of distributing the power from the Centennial engine through an elaborate system of shafting with both gear and belt drives. This needs no repetition for the present purposes, but more in detail is in order concerning the engine itself, which will include some of the principal facts already given.

The Centennial engine had its cylinders and means of connection with the single flywheel, in duplicate, so that it was strictly a pair of beam engines, although connected as one unit. George H. Corliss, of Providence, R. I., was the inventor and manufacturer. The engines were designed to work expansively, with steam at an initial pressure up to 80 lb. The valves and valve gear were Corliss type with several improvements specially designed for and first applied to these engines. The cylinders were 40 in. diameter and the stroke 10 ft. Each of the beams was 27 ft. long by 9 ft. deep and weighed 11 tons. The flywheel, to the shaft of which the engines were connected at right angles, was a cut-gear wheel 30 ft. in diameter by 2 ft. face width and weighed 56 tons. It made 36 r.p.m., giving a piston speed of 720 ft. per min.

The pinion which the flywheel drove was 10 ft. diameter and weighed 8½ tons. This rotative speed is in marked contrast to that of both the turbines, which is the big factor in accounting for the disparity of sizes between the two types of machine. It is a fundamental law that the power developed increases as the speed so, naturally enough, increasing the speed a hundred times means a greatly reduced size of prime mover.

An interesting comparison, if it could be made, would be that of steam consumption per horsepower-hour, but unfortunately Mr. Corliss would not allow the figures to be given out for his engine, if indeed they were ever determined by test; but doubtless a better economy would have been shown by the Centennial engine in spite of the lower steam pressure used, the absence of superheat in the steam, and the use of live steam in the cylinder jackets. The engine developed 1400 hp. and could be driven up to 2000 hp. when required. The platform on which the engine stood was 55 ft. diameter, or 2376 sq.ft. area, so that it is fair to consider this as the floor space occupied. The total height was 39 ft. and the total weight 700 tons.

Striking by contrast are the figures for the turbine of the same power shown beneath the engine. As before stated, it runs at 100 times the speed, or 3600 r.p.m., but it occupies only $^1/_{20}$ the floor space, or 119 sq.ft., and weighs about $\frac{1}{32}$ as much (22 tons). Its height is less than ⅕ as great (7 ft.), but it uses nearly twice the steam pressure (150 lb.). The turbine shown in this instance is of the Curtis type, as built by the General Electric Co., rated at 1000 kw., which is very nearly the equivalent of 1400 hp. If anything, the turbine is more powerful than the engine, for the brake horsepower developed by the turbine would be more, there being some loss in the transformation to electrical energy through the generator.

The picture at the bottom of the page is that of the 30,000-kw. so called cross-compound Westinghouse-Parsons type turbine built by the Westinghouse Machine Co. and the Westinghouse Electric & Manufacturing Co. for the Interborough Rapid Transit Co.'s Seventy-Fourth St. station in New York City.

In some ways it makes a better type to compare with the engine, for it is also practically two machines and occupies very nearly the same floor space—51 by 40, or 2040 sq.ft. Therefore, whereas in the first case the Centennial engine was compared with a turbine of the same power, here it is compared with one of the same size and, incidentally, nearly the same weight—900 tons. The power, even allowing for no losses between the turbine and its generator, is seen to be nearly 29 times as great (40,200 hp.), the steam pressure 2½ times as much (200 lb.) and the speed of the high-pressure rotor 42 times as much (1500 r.p.m.) and that of the low-pressure rotor 21 times as much (750 r.p.m.).

The use of two speeds is a notable advance in the design of this form of prime mover. To get the most suitable blade speeds for both the high-pressure and the low-pressure steam in elements all on one shaft and avoid severe stresses, involves mechanical difficulties. Using a high speed for the high-pressure element and a slow speed for the low-pressure overcomes these difficulties.

1876 DEVELOPMENT OF STEAM-POWER UNITS 1915

THE ILLUSTRATIONS ARE ENGRAVED IN THE SAME RELATIVE PROPORTION AS THE DIMENSIONS OF THE UNITS

CYLINDERS
Diameter 40 in.
Stroke 10 ft.

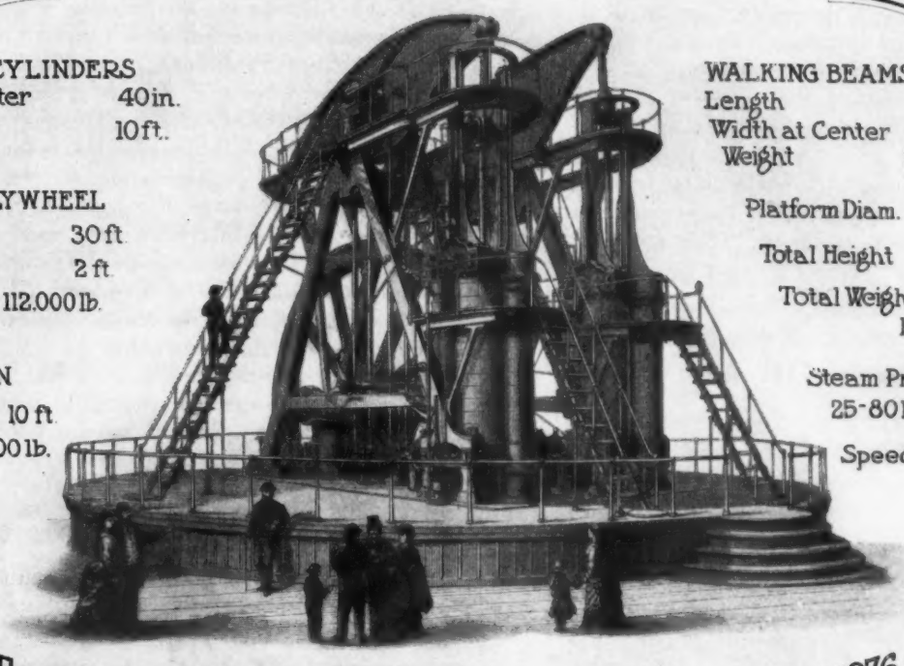
GEAR FLYWHEEL
Diameter 30 ft.
Face 2 ft.
Weight 112,000 lb.

PINION
Diameter 10 ft.
Weight 17,000 lb.

WALKING BEAMS
Length 27 ft.
Width at Center 9 ft.
Weight 22,000 lb.

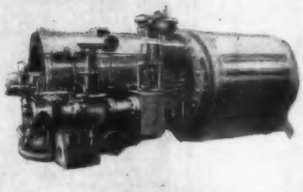
Platform Diam. 55 ft.
Total Height 39 ft.
Total Weight 1,400,000 lb.

Steam Pressure 25-80 lb. per sq. in.
Speed 36 r.p.m.



The 1400-hp. CENTENNIAL CORLISS ENGINE of 1876

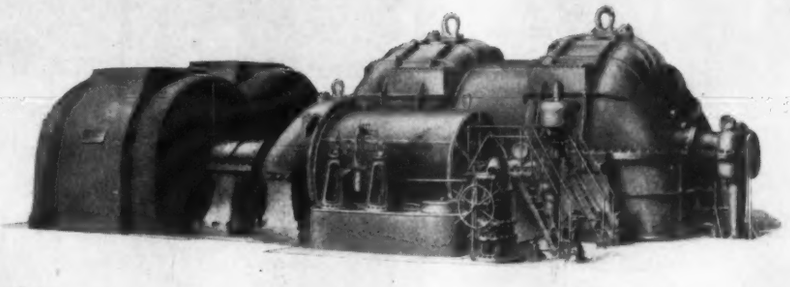
Length 17 ft.
Height 7 ft.
Weight 44,000 lb.



Steam Pressure 150 lb. per sq. in.
Speed 3600 r.p.m.

A 1400-hp. CURTIS-TYPE TURBO-GENERATOR of 1915

Length 51 ft.
Height 13 ft.
Weight 1,800,000 lb.
Steam Pressure 200 lb. per sq. in.



SPEEDS:
High-pressure Rotor 1500 r.p.m.
Low-pressure Rotor 750 r.p.m.

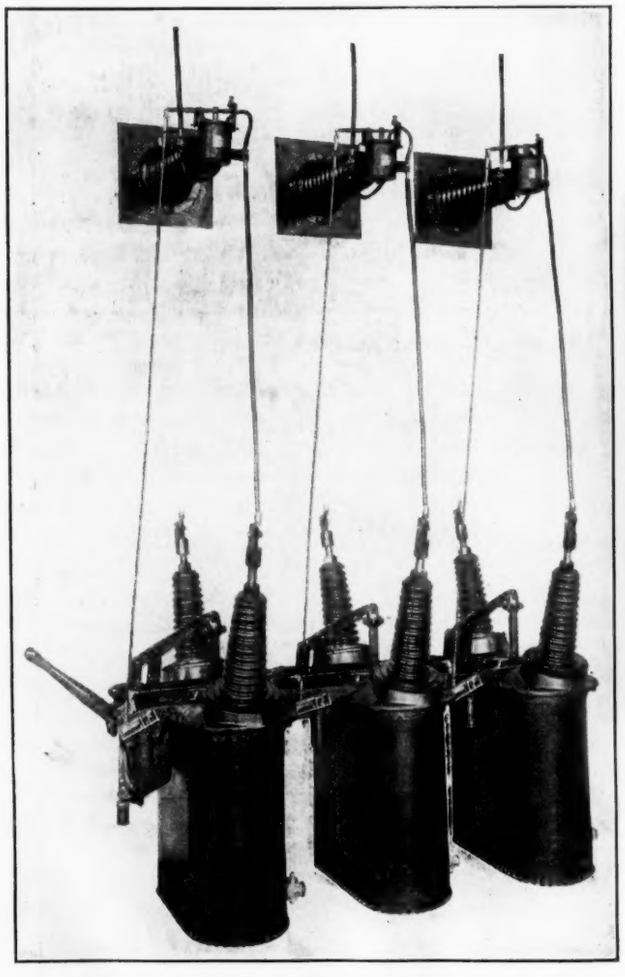
A 40,200-hp. PARSONS-TYPE TURBO-GENERATOR of 1915

In addition to the dissimilarity dimensionally, there is not the slightest resemblance in form between the machines at the bottom and top of the page, yet within a period of forty years both have been designed to perform the same work—to convert the heat energy in steam into work.

Some of the advantages which the later form has over the earlier have been mentioned. Another is its ability to use steam at very low pressures, say 26 to 29 in. vacuum. The reciprocating engine becomes prohibitively unwieldy when it carries the expansion of steam into a very high vacuum, and the excessive condensation offsets the desirability of low exhaust pressures. That is when the turbine as a coworker with the engine comes in, and in the future we shall probably see more and more of the combination units—reciprocating engines exhausting into steam turbines. Thus are the rivals becoming partners.

New Series Trip for High-Voltage Oil Switches

Low-voltage current is usually employed to trip high-voltage automatic oil switches on the occurrence of abnormal conditions against which the automatic features are intended to guard. Electrically operated switches are usually tripped by direct current, and for tripping hand-operated switches alternating current is generally used. In many instances, however, neither low-voltage direct current nor alternating current is conveniently or cheaply available, in which case automatic protection is secured by the use of a high-voltage series trip.



45,000-Volt Oil Switch with Triple-Pole, Time-Limit, Series Trip

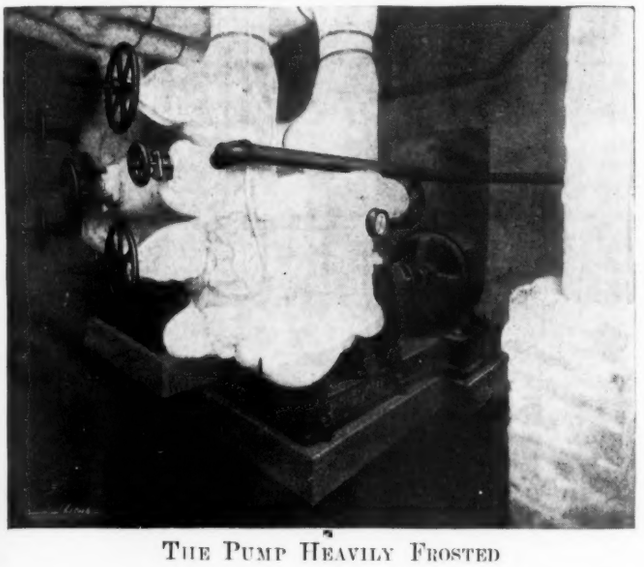
For this service the General Electric Co. has developed an arrangement representing an improvement on types of high-voltage series tripping devices heretofore in use. The new features are accessibility of the working parts for inspection, cleaning or adjustment while in service, without danger; calibration at the oil switch itself and not at the insulator supporting the series tripping solenoid; and the use of a new type of solenoid, consisting of a few simple and rugged parts that need practically no attention after installation.

The solenoid plunger is connected to the tripping mechanism of the oil switch by a wooden rod. Calibration, that is, change in current tripping values, is accomplished by a movable weight located near the operating mechanism of the switch, at a considerable distance from the high-voltage current.

This type of series trip is furnished for instantaneous or inverse time-limit operation. Time delay is obtained by means of a dashpot mounted on the tripping mechanism at the switch.

Good Service from Brine Pump

The illustration shows two brine pumps at the plant of the Independent Packing Co., Chicago. One of these units has been working 24 hr. per day for nearly a year without a stop for repairs. Covered with four to five inches of ice, it has run continuously at about 900 r.p.m. against a head of 20 lb.



The Pump Heavily Frosted

The pump is of the two-stage, all-bronze centrifugal type, made by the American Well Works. It has a capacity of 500 gal. per minute and is driven by a variable-speed direct-current motor. When starting the brine through the system, the pump requires about 27 hp. The speed is boosted to 1300 r.p.m. and the head is about 80 lb. When the brine is in circulation, the speed is lowered and only about 8 hp. is required to drive the pump. The second unit is held as a reserve, as there is danger of freezing the system.

Editorials

The Most Suitable Firebrick

The need of adapting the fuel to the furnace and *vice versa* has long been recognized. Adapting the refractory lining of the furnace to the temperature ranges and character of fuel is, at most, meagerly practiced, if at all in boiler work. It is common to line the furnace with one kind or grade of refractory material, yet the brick in contact with the fuel and ash is subjected to conditions never imposed upon that above the fire line. The latter is exposed chiefly to high temperatures only, while that below, besides being highly heated and carrying the load due to the weight of the brick above, is subjected to the chemical influences of the slag of the fused ash. Clinker tends to stick to the brick. When hit with a bar to loosen it, the brick is usually broken away where the clinker joined.

It would seem worth while, as pointed out on page 297, to use in most plants a highly refractory, tough, nonfrittering though expensive brick for that part of the furnace lining below the fire line, while a cheaper grade could be used above. The coal that will give the greatest number of pounds of water evaporated per unit of cost is best for the plant. Should not the refractory material that will give the longest service per unit of area or volume per unit of cost under the existing furnace temperature ranges be most suitable?

Synthetic Fuel

Fuel is capable of producing energy because it has the capacity of combining chemically with something, the union producing heat. The rise in temperature is simply an increase in the velocity with which the molecules move.

If a weight is in contact with the earth it has no inherent energy with respect to the earth. It cannot fall. Place it at an elevation, and it has potential energy which it can exert in other forms, as does the hammer of a pile driver or the weight of a clock.

The atoms of carbon and hydrogen in fuel attract, and are attracted by, atoms of oxygen, as the earth and the weight attract each other. When this attraction is sufficient, as in the furnace, to overcome the existing arrangement they rush together, gathering velocity and momentum, as does the weight falling to the earth. They do not impact and lose this velocity, as do the weight and the earth in overcoming the resistance of yielding substances or setting up molecular vibration at the point of contact (the heat of impact), but vibrate about each other like miniature planetary systems, with a vastly increased velocity. Their temperature is a function of this velocity and their mass; a measure of their momentum.

When they come in contact with the molecules of the boiler plate they set them into more active vibration, and this vibration is passed on to the molecules of the water, inciting them to such rapidity of motion that they break away from each other and fly off, like stones from a slingshot, impacting upon the walls of the containing vessel and producing by their bombardment that which we recognize as pressure.

The gases, cooled (having imparted a part of their velocity or momentum to the atoms of the heating surface), pass off to the atmosphere. They are in the condition of the weight and the earth which have come together; the clock which has run down. They cannot get up any more velocity or momentum in themselves by falling any closer. How, then, are they to be separated that they may be again available as media of energy?

When the carbon combines with the oxygen they form carbonic-acid gas, the gas which makes the bubbles at the soda fountain and gives the sparkle to wine. When hydrogen combines with oxygen they form water. To decompose the carbonic-acid gas or the water, that is, to dissociate these molecules into atoms of carbon or hydrogen and oxygen, takes as much energy as is generated by their combustion or coming together.

And here comes in one of the most wonderful, beautiful and mysterious of Nature's processes, described in this way in an old school chemistry, the name of the author of which we do not recall: It is a peculiar property of vegetation that under the influence of sunlight it can overcome the attraction which exists between the atoms of carbon and oxygen, appropriating the carbon to its own use, building it into its structure, and letting the oxygen go free into the atmosphere. To separate these elements in our laboratories, we are obliged to resort to the most powerful chemical agents and to conduct the process in vessels composed of the most refractory material, under all the violent manifestations of light and heat; and we then succeed in liberating the carbon only by shutting up the oxygen in a still stronger prison. But under the quiet influence of the sunbeam, in that most delicate of all structures, a vegetable cell, the chains which unite together the two elements fall off, and while the solid carbon is retained to build up the organic structure, the oxygen is allowed to return to its home in the atmosphere. To separate a pound of carbon from the oxygen with which it unites in burning would require the expenditure of an amount of energy which would raise the weight of a ton to a height of over a mile, and yet, in the economy of Nature, this process is constantly going on, not with the noisy demonstration of prodigious effort, but quietly, in the delicate structure of a green leaf waving in the sunshine.

The most promising direction in which to look for a more direct or rapid process than that of waiting for fuel to be produced by the slow growth of vegetation is through the discovery of the secret of the vegetable cell, and the application of the sun's energy either to the direct production of other forms or to the synthetic production of fuel. At a meeting of the French Society of Civil Engineers some time since, M. Daniel Bertholet said that, working in conjunction with M. Gaudechon, he had suc-

ceeded in producing the principal sugars by acting with ultra-violet light on a mixture of gaseous carbon dioxide and water. In a further set of experiments compounds of carbon, oxygen, hydrogen and nitrogen were produced by acting with these ultra-violet rays on a mixture of carbon dioxide and ammonia. In these conditions the carbon dioxide is decomposed just as it is by chlorophyll under the action of sunlight. Activity in this direction would be much more promising than that in the direction of the fuel mixtures, of the rise and decline of which so much has recently appeared in the public prints.

Keeping Track of Plant Operation

Plant revenue is derived from plant output, but for many years the switchboard output was the only thing about the plant that was metered except where the local authorities applied a water meter to the service pipe. Of course, the monthly payroll, repairs and the cost of fuel, oil and supplies were recorded, and in a few cases the weight of the coal fired was noted. Occasional indicator diagrams were taken on the engines, and some plants were tested when new. Records along these lines were at one time considered the last word in refinement, although there were some who strenuously maintained that there was a big gap between the grate bars and the switchboard, where serious plant losses might occur undetected. One of the difficulties to be overcome in isolating these losses was the supposedly fragile nature of the instruments required and their unsuitability to the boiler room.

When the steam turbine came into general use in central stations the steam-engine indicator retired, and then there really was nothing between the grate bars and the switchboard to tell what was happening except the recording steam-pressure gage. The first instrument to become a factor in boiler-room operation after this was the CO_2 meter. This revealed many sources of leakage and expense without adequate return and put a premium upon complete combustion. The Orsat apparatus revealed high oxygen and checked the combustion recorder. Between these two lies the responsibility for a general advance in fire-room practice and the patching up of boiler settings. The disadvantage resulting from porous brickwork brought the marine type of setting to the attention of power-plant engineers, and sheet-steel casings are not uncommon in modern practice.

Extended experience, however, showed that there were still uncovered sources of waste. High CO_2 occasionally failed to be an accurate index of economy, particularly where a number of boilers were employed and premiums paid. Instances occurred where it took more boilers to carry the load than were absolutely necessary, or low steam pressure somewhere was revealed by an unexpected jump in the load curve. The investigation of uptake temperatures and draft pressures furnished a partial cure for the trouble, but the final check was the use of the steam meter and the feed-water meter.

Incidental to the introduction of these instruments came the close study of boiler settings, boiler output and the possible increase in power output, increase in grate area and large boilers. It took years for the metallurgical engineer to learn that the low-roofed furnace designed to force the heat into the bath by close contact with the flame was a mistake. He raised the roofs of his furnaces, gradually learning that the larger combustion chamber and the radiant heat resulted in economy of fuel and reduced roof repairs. Today the same lesson is being brought to the attention of those interested in boiler output along economical lines. The published tests of the Delray boilers and the tests and operating results secured in the new Cleveland municipal plant indicate what the boiler room can do.

License Legislation in Massachusetts

A new engineers' license law (House Bill 1111) is before the Massachusetts legislature and is occasioning a great deal of interest. It appears under the patronage of a voluntary committee, which has headquarters in the Sears Building, a secretary in the person of Richard B. Stanley, and representatives from the paper, pulp, cotton, woolen, metal-working, quarry and lime industries, and the boards of trades. The difference between the present and proposed laws is thus set forth by the propagandists:

PRESENT LAW	PROPOSED LAW
It recognizes no difference in the risk of operation between steam engines and steam boilers.	It recognizes much difference in the risk of operation between steam engines and steam boilers.
It fails to determine the scope of examinations and to require them to be uniform throughout the state.	It determines the scope of examinations and requires them to be uniform throughout the state.
It permits the requirement of knowledge of the principles of design in the examination of applicants for licenses to operate.	It limits to knowledge of operation the examination of applicants for licenses to operate.
It permits the requirement of knowledge of the principles of design of boilers in the examination of applicants for licenses to operate engines.	It limits to knowledge of engine operation the examination of applicants to operate engines.
It permits the examiner to require involved mathematical calculations, thereby denying employment to competent men.	It prevents the examiner from requiring involved mathematical calculations.
Complex and difficult to understand.	Simple and clear.

The bill appears, probably from oversight, to fail to forbid the operation of engines between twenty-five and one hundred and fifty horsepower without a licensed engineer, and is evidently designed to forestall any attempt to restrict the supply of available engineers and firemen by subjecting them to an impassable examination and to the requirement of a licensed man for everything about the power house from superintendent to coal passer.

Another bill (House Bill No. 19) puts into effect, if passed, the recommendations of the Chief of District Police with regard to the examination and certification of inspectors of boiler-insurance companies.

Some Dates to Remember

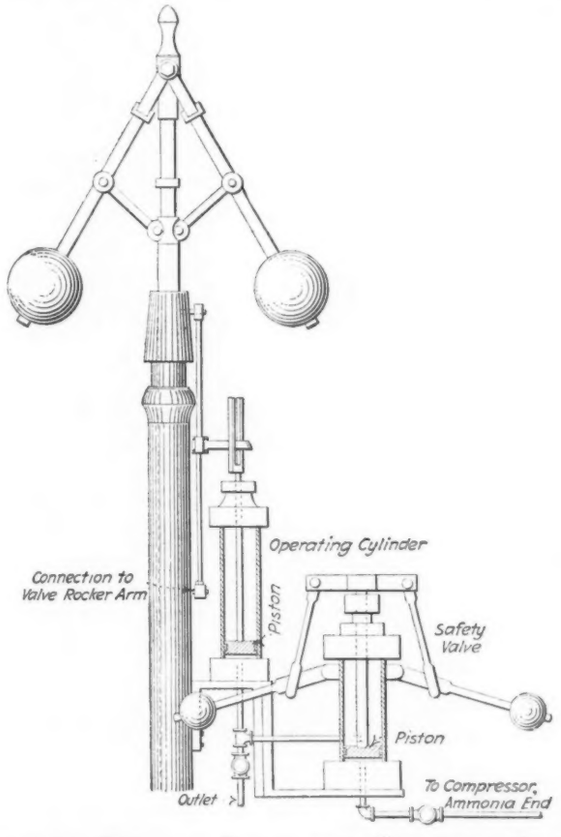
Dec. 15, 1912, Hall of Records Test begun.
Dec. 15, 1913, Hall of Records Test finished.
Mar. 2, 1915, Advisory board of engineers still debating.

Would fourteen months of silence have followed the conclusion of the test had the figures favored the New York Edison Co.?

Correspondence

Operating Refrigeration Plants Safely

At present there is much needed discussion of safety in refrigeration plants published in POWER. The use of safety valves does not meet with general approval, and there are several good reasons for this. After a safety valve has been set to operate at a certain pressure, say 300 lb., it may be a long time before the pressure from any cause will reach a point that will cause this valve to open. All ammonia plants are troubled with dirt, scale and chunks of litharge and it is almost impossible to



AMMONIA PRESSURE RAISES THE GOVERNOR, GIVING EARLIER CUTOFF, THEREBY REDUCING THE COMPRESSOR SPEED

clean these completely out of the piping system. Some of this foreign matter will be carried along with the escaping ammonia and deposited on the seat of the safety valve, preventing it from closing tightly, though it be of the best design. The idea of using a body of water as an absorbent has been completely answered by Mr. Fairbanks, of Boston (see POWER, Dec. 15, pp. 849 and 866), and the writer will not touch on that point here. The various laws of different states regulating the operation of steam boilers (notably those of Massachusetts, which some consider to be the best) are useless unless strictly lived up to. This is mentioned only to illustrate that, no matter what safety device may be ordered by law for the safe operation of refrigeration plants, that device will be of no avail unless it is of such design that it can be easily looked after and kept in good working order at all times.

Investigation of numerous accidents to refrigerating plants has proved that a large percentage were due to the carelessness of someone operating the plant. The most destructive accidents may be summed up as those caused by excessive pressure from the loss of cooling water on the condenser, not opening the discharge valve from the compressor to the condenser after the former had been pumped out for packing the rod or other repairs, or from a heavy charge of liquid being carried over from the low-pressure side of the system, and in a lesser degree the breaking of a follower plate or a valve stem, which in either case must cause the destruction of the compressor regardless of any and all safety devices on the market.

I make it a practice to replace all suction valves that open into the compressor, after they have been in continuous use two years. This is done on the assumption that the constant hammering that they are subjected to must cause crystallization. In fact, I once broke a valve stem that had been, as near as I could learn, in continuous use about five years, by striking it a sharp blow with a small hammer. Within the past year one of our compressors developed a badly cracked follower. I mention these things to show that fatigue or weakening of parts is a cause of danger that cannot receive too careful consideration by owners and operators.

There are two devices for preventing an excess pressure being generated in a refrigeration system that have come under my observation. One consists of a small safety valve piped directly from the compressor cylinder, that discharges into a cylinder fitted with a piston, the crosshead of which engages the governor stem. When the pressure in the compressor cylinder exceeds a predetermined point, say 200 lb., the safety valve admits ammonia to the pressure-regulating cylinder, lifting its piston, which in turn lifts the governor spindle and disengages the hooks so that the steam valves cannot be opened by the valve gear, and the engine comes to a stop. This works well on a machine with one steam cylinder, as this device has no method of breaking the vacuum, as in a compound condensing machine. It is not as quick in action as the method now employed by the writer and which has given satisfaction for over six years. The refrigerating machine has an engine stop, and the ends of the ammonia compressor are piped to a pressure gage so designed as to permit the use of the pointer as an electric switch to close the electric circuit putting the engine stop in motion. This action closes the throttle and breaks the vacuum, stopping the machine in as short a time as seven seconds. The device is adjusted to operate at 200 lb., and in very hot weather, when the working pressure has been close to that point, it has been found impossible

to keep the machines in operation until the head pressure had been lowered. The stop is also equipped with a remote control, with six stations located in different parts of the engine room and one general station outside the building, where, by breaking the glass and pulling down a lever, the power plant can be brought to a standstill. A system of this kind that prevents the generation of an excessive pressure in the refrigerating system is the best means of promoting safety in handling large quantities of ammonia.

In case of a fire that would be likely to destroy a building used for refrigeration purposes, there would be little choice between blowing the high-pressure ammonia from a pipe ten feet higher than the building and allowing the building to collapse, bursting the ammonia pipes. It is commendable practice to carry ammonia relief pipes to the top of the smoke-stack.

H. W. Geare.

New York City.

Repairing Crack in Combustion Chamber

About two years ago a combustion chamber on one of our 1000-hp. gas engines cracked from top to bottom, a distance of about 14 in. This engine is used as an auxiliary and has not been run very much since then. When the crack first developed, the cylinder could be used by starting the engine with no water in the jacket, the crack closing by expansion due to the increased temperature and preventing the water from entering the cylinder. The opening seemed to become larger, however, and finally the cylinder could not be used at all.

At first it was thought useless to try to repair the break, but later, representatives of two welding firms were consulted. One agreed to weld the crack at an exorbitant figure, but would not guarantee the job; the other expressed the opinion that it could not be repaired.

After this I asked permission for a trial at repairing it, which was granted. I began the job with Smooth-On cement and 5/8-in. Norway-iron studs. The second hole was drilled so as to cut into one-third the diameter of the first, and so on all the way up the crack. The studs were screwed in with the iron cement, cut off and slightly peened. The repair proved successful.

J. B. Linker.

Charlotte, N. C.

Starting a Small Motor

In the Jan. 12 issue Walter S. Griscom tells of difficulty in starting a small motor. This trouble was undoubtedly due to a weak field, which in turn, was probably caused by low voltage at the motor terminals, due to drop resulting from a long length of small wire or bad or loose connections. Such a drop will be aggravated by an increase in amperage, and a shunt motor under these conditions may have little field strength and possibly not enough torque to start the motor. Putting resistance in the armature circuit would partially overcome this difficulty, but I fail to see the necessity for leaving the lamps in circuit after the motor is up to speed.

Several years ago a motor-generator was set up and operated in our plant by a young fellow who didn't care to have anybody advise him. He was never able to start the machine without help and a careful manipulation of the starting box. The machine was later turned over to me, and I found that the connections on the starting box had been made so that the field was in series with the starting resistance. After changing this the motor started promptly.

I have also seen the experiment tried of electrically connecting two 50-kw. shunt-wound machines while idle, and attempting to bring both up to speed together, one acting as a generator and the other as a motor. The main circuit-breaker would invariably trip without noticeable indication on the voltmeters or without producing appreciable torque in the second machine.

H. L. Strong.

Yarmouthville, Maine.

Who Gets the Promotion?

Concerning the Foreword in the issue of Dec. 15, 1914, and Mr. Farnsworth's deductions on page 172, issue of Feb. 2, 1915, I can see no reason for saying that only one of the men has made preparation for the position. Neither can I agree with him that the manager has no right to consider his own likes or dislikes in the matter. I think that any engineer will agree that he can do a whole lot better with a plant where he is on good terms with the boss than otherwise. A man who is popular with his mates will be more likely to have harmony among his men when he gets to be the chief than a man who is ill tempered, surly or just plain cranky. I say this from experience. Neither will they resent his authority as much as they would if he were a grouch. I have heard men say behind my back when I was foreman: "Yes, he looks and acts like a kid when he is playing with the boys, but when the whistle blows he knows how to handle his men, and if he tells you to do anything, you had better do it." I could skylark with the boys or men of my crew outside of working hours and maintain discipline among them when on duty, and I have the reputation of getting the best possible service from my men.

Because a man is grouchy, this does not unfit him for the position, but everything else being equal, the cheerful man will have more harmony and stand a better chance of success. Personally, I would feel more like doing my best for the man who would treat me like a chum than I would for one who would hardly say "Good morning" civilly.

If a man is steady, sober and honest, does it not count for many points in the promotion game? Of course, if these are the only points they are not sufficient, but if he has seen long service he must have acquired considerable ability. Of course, there are men who make good assistants but very poor chiefs, and the ideal chief is one who will combine the good qualities of all three; such men are born, however, not made, and this is the reason that we often see a young fellow installed as chief while his assistants are double his age and experience, yet lacking the knack of control.

However, all this does not help the manager to decide, but if I were in his place I believe I would choose the one with the cheerful temper if I liked him personally. I think being a hustler does not imply being always hurrying or on the run.

A. A. Blanchard.

Oxford, N. J.

Notes on Indicator Diagrams

While it is obvious that the indicator diagrams shown in POWER, Nov. 3, 1914, p. 650, are due to a slipped eccentric, it is not evident that the rod is out of adjustment. Granting that the diagrams were taken from an engine with a simple slide-valve, both adjustments are at fault. While the data given are not complete, it is possible to show that if the shaft were 4 in. in diameter, the engineer would need to lay off with dividers $2^3/_{64}$ in. and advance the eccentric that amount. For the engine in question this would need to be multiplied by the ratio of the diameter of its shaft to 4 in.

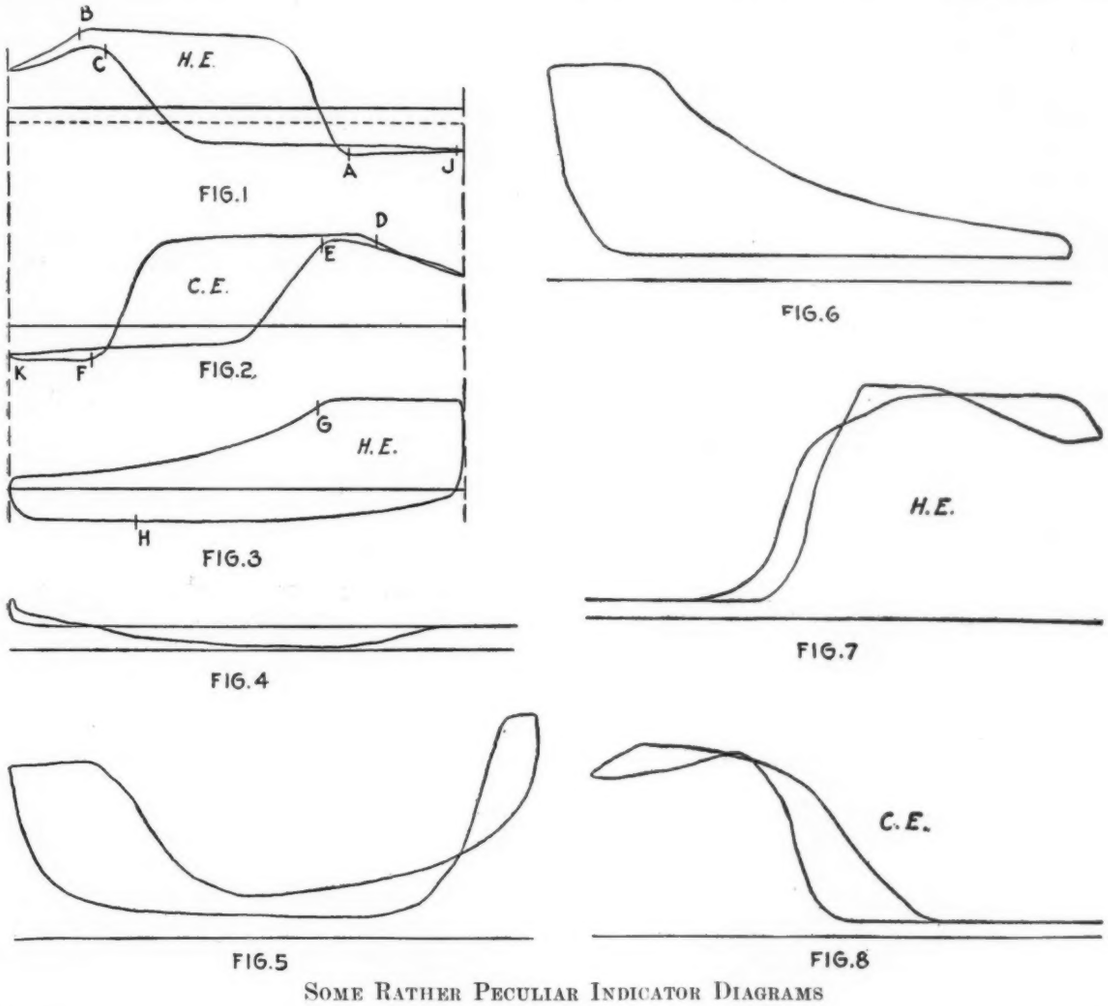
This is easily done graphically by drawing the shaft circle to scale and a 4-in. circle concentric with it. Lay off on the latter a chord as given and continue radial lines through its ends to the shaft circle. It would be easier in laying this out on the shaft to use two chords of $1\frac{1}{16}$ in. (on the 4-in. shaft) instead of one. This ratio is the scale factor of the diagram used to get the data given below. The rod should also be lengthened $\frac{3}{32}$ in. multiplied by this ratio.

Since no information is given regarding the compounding of this engine, no speculation has been made concerning the action of this low-pressure cylinder or the effect on the revised diagram. Figs. 1 and 2 show the original diagrams traced with events marked. Fig. 3 gives the card obtainable under favorable conditions with the correct setting as indicated, but with the same terminal pressures. In the original diagram, Fig. 1, the atmospheric line is about 5½ lb. too high. It should be where the dotted line is, though this does not affect the diagram so far as valve analysis is concerned. The crank-end diagram is similar.

	1 Per Cent. Stroke	2	3
Admission	A - 25	F - 19%	Near dead center.
Cut off	B - 84	D - 81	G - 32%
Release	C - 78	E - 64	Near end of stroke.
Compression	J - 2	K - 0	H - 72%

Interesting freak diagrams, Figs. 4 and 5, are from the head and crank ends of a 7¾x15-in. piston-valve engine, normal speed, 220 r.p.m. This 35-hp. engine was not running over 100 r.p.m. at the time the diagrams were taken. Fig. 6 is from the head end taken after setting the valves. The crank-end diagram is similar, though at this time it was not quite as perfect. Diagrams 7 and 8 were taken under similar circumstances from the same engine. This condition of the valves is one that might result from the breaking of an inner valve ring, where the ring caught between the two valves and slipped the rods and the eccentrics—an accident that has occurred on this type of engine.

To those interested in valve setting, these diagrams should claim attention, for to correct faults it is often necessary to locate all the events, though the action is complicated here by the relative movement of the two valves.



SOME RATHER PECULIAR INDICATOR DIAGRAMS

The valve gear is such that the main valve is indirect, as it takes steam on the inside, has a travel of 2⅜ in. and a nonreversing rocker. The eccentric is some thirty inches behind the crank.

The rider valve eccentric is about thirty degrees ahead of the crank when the governor is down and some ninety degrees ahead when running light. Its valve is also indirect, as its motion is reversed by a rocker pivoted at its center to the center of the main valve rocker. The valve takes steam on the outside and its travel, both relative and absolute, varies. The latter is about 3½ in. when the governor is down and may be from 4 to 4⅜ in. when carrying a load, varying with the load and with the setting.

Because of this variable valve travel a valve diagram does not represent the movements of the parts as well as it does for the simpler valve gears, such as the Meyer.

The results of a Zeuner diagram for the first two diagrams may be of interest. Taking, for convenience, a 4-in. valve travel and a connecting-rod five times the length of the crank, it is found that the events check as shown. For the final setting, which was made for $^1/_{64}$-in. lead on the head end and for equal cutoffs, we have the following:

End	Admission	Cutoff	Release	Compression	Steam Lap, In.	Dead, In.	Port Opening Steam, In.	Port Opening Exhaust, In.
Head	0	32	99	72	1¼	1/16	1/16	¼
Crank	0.5	32	99	68	1⅛	1/16	1/16	1/16

These port openings are the maximum possible and must be compared with the actual ports to get under travel. All dimensions, except the percentages of stroke, must be multiplied by the ratio of the actual valve travel to 4 in.

A. R. NOTTINGHAM.

West Lafayette, Ind.

Stopping a Low-Pressure Complaint

The editorial, "The Wrong Slant," in the Dec. 15 number, calls attention to the status of the steam engineer in most factories. Besides being an "expense" he is often the "goat" for any accident that may occur which reduces the output of the factory. The power item being large in the production of some articles, the engineer is often held accountable for losses, and sometimes when he is in no way responsible. Even when he is not charged directly with the responsibility for losses, he is informed that the loss in department so-and-so was due to a drop in steam pressure or to a few minutes' interruption of light or power service, and this in a tone which leaves him with the impression that life is just one thing after another.

In a factory making food products, where much steam was used for cooking and drying, the foremen of the different departments seemed prone to charge their short or otherwise unsatisfactory outputs to a drop in steam pressure. This so got on the nerves of the master mechanic that he persuaded the manager to buy a recording pressure-gage. This was fixed to the wall above the master mechanic's desk and connected to the steam main in the boiler room, which was in the adjoining building.

A few days later the manager sent for the master mechanic and informed him that the output of Mr. Jones' department had been seriously reduced the night before on account of a great drop in the steam pressure. The master mechanic produced the chart taken from the gage at 7 o'clock that morning and showed that during the previous 24 hr. there had been no abnormal variation in the pressure and that the statement of Mr. Jones was just a plain lie. The manager must have had a heart-to-heart talk with Mr. Jones, because late in the afternoon Jones called on the master mechanic and had quite a lengthy but friendly chat. No reference was made to steam pressures, but Jones kept his eyes on the pressure gage throughout the conversation. As he was about to leave he pointed to the gage and asked, "What is that thing there?" "That?" said the master mechanic; "O, that's a trap to catch four-flushers."

C. O. SANDSTROM

Kansas City, Mo.

Quarter-Turn Rod Coupling

Under the above title, on page 117 of the Jan. 26 issue, there is reference to a device patented by C. P. Hall, of the Rookery Building, Chicago.

If my memory serves me rightly a coupling of this construction was designed by William G. Bond, chief engineer for the National Biscuit Co., Tenth Ave. and Fifteenth St., New York City, some fifteen years ago, and it may now be in service in that plant.

I was in charge of the electrical equipment and assisted Mr. Bond in the preparation of the working drawings of a coupling that I am almost positive was similar in every way to the detail you have shown.

NEWTON L. SCHLOSS.

New York City.

Grouting under Heavy Machinery

I have seen engine erectors use neat cement for grouting under engines. This, I believe, makes a grouting inferior to a mixture of one part cement and one part clean sand, or even two of sand to one of cement. While neat cement gets very hard, it cracks easily.

It is a matter of considerable discussion whether, in setting engines, the leveling wedges should be left in or taken out after the grouting has set. With the wedges in, almost the entire weight of the engine remains on them, as the grouting will not set up tight enough to take the weight and the engine is much more apt to work loose on its foundation.

I once had a three-cylinder vertical, direct-connected engine that worked badly. The engine was raised a quarter of an inch, the old grouting knocked out and some four hundred pounds of sulphur run under the base. Sulphur was used because the foundation had become so oil-soaked that it would have been impossible to get a cement grouting to bond. That job was done more than four years ago and the engine does not show the slightest movement.

In doing this work it was found that a wedge had been left under each side of the base at about the center of the engine. If these wedges had been pulled out in the first place, the engine would never have started working as it did; it was simply rocking on the wedges.

D. N. MCCLINTON.

Pittsburgh, Penn.

Inquiries of General Interest

Rerolling of Boiler Tubes—When a return-tubular boiler has been in continuous use for five years, the tubes having been rerolled a number of times, is it possible to cut off the tube ends by further rerollings?

F. C. T.

If the boiler tubes are rerolled in such a manner that they are each time expanded inside of the tube sheet, then a sufficient number of rerollings will cause the tube ends to split or to break off, especially if the tube material has become weakened by corrosion.

Breakage of Shafts in Hubs of Pulleys—What reason is to be assigned for repeated breakage of our shafting inside of the hubs of driving and receiving pulleys?

J. O. B.

The shafts break in the hubs of the pulleys because those are the points where, mainly from tension of belts, the shafts are subjected to greatest bending stresses. The remedy is to reduce the bending stresses by placing bearings closer to the pulleys or using larger pulleys, thereby transmitting the same power with less belt tension and also less journal friction.

Relative Water Used by Refrigerating Systems—Is there any difference in the quantities of water required by absorption and by compression systems of refrigeration of like capacity?

G. B.

It is customary to use a little more water for absorption systems than for compression systems having simple steam engines. When compound condensing engines are used for driving compressors the water used to obtain 26 in. vacuum is about the same as required for a standard absorption system of equal refrigerating capacity.

Latent Heat of Fusion and of Evaporation—How many B.t.u. must be added to 1 lb. of ice at 32 deg. F. to melt it to water at the same temperature; and how many B.t.u. must be added to 1 lb. of water at 212 to convert it into steam at atmospheric pressure?

F. A.

The heat required to melt a pound of ice at 32 deg. to water at the same temperature is 144 B.t.u., this being the latent heat of fusion of ice. Conversion of a pound of water at 212 deg. F. into dry saturated steam at atmospheric pressure, requires the addition of 970.4 B.t.u., called the latent heat of evaporation at atmospheric pressure, one B.t.u. being taken as $^1/_{180}$ of the heat required to raise a pound of water from 32 to 212 deg. F.

Conversion of Gage Readings into Absolute Pressures—With a barometric reading of 29.4 in. what would be the absolute pressures corresponding to 100-lb. gage pressure and 26-in. vacuum?

C. R.

Assuming that the barometric and vacuum gage readings are, as usual, based upon heights of mercury columns at a temperature of 62 deg. F., at which temperature an inch of mercury column is equivalent to 0.491 lb. per sq.in., then for a barometric reading of 29.4 in. a gage pressure of 100 lb. would correspond to

$$100 + (29.4 \times 0.491) = 114.435 \text{ lb. per sq.in. absolute}$$

and 26-in. vacuum would correspond to

$$(29.4 - 26) \times 0.491 = 1.669 \text{ lb. per sq.in. absolute.}$$

Temperature of Steam at Reduced Pressure—If dry saturated steam at 85-lb. gage pressure is passed through a reducing valve what will be its temperature if reduced to 4-lb. gage pressure?

Q. W. D.

By referring to Marks and Davis' steam tables it may be seen that each pound of dry saturated steam at 85-lb. gage pressure, or 85 + 15 = 100 lb. absolute, contains 1186.3 B.t.u. above 32 deg. F. Neglecting the heat lost by radiation and in work overcoming friction in passing through the reducing valve, which under ordinary circumstances would be negligible, each pound of the steam at the reduced pressure of 4 lb. gage, or 4 + 15 = 19 lb. absolute, may be regarded as containing the same number of heat units as in the original condition, viz., 1186.3 B.t.u. above 32 deg. F. Referring to the same tables of heat of steam at various pressure and with different degrees of superheating, it is found that the temperature of dry saturated steam at 19 lb. absolute, when saturated, contains only 1155.2 B.t.u. per pound above 32 deg. F., and the temperature is 225.2 deg. F., but when superheated 60 deg. F. each pound contains 1183.6 B.t.u., and when superheated 70 deg. F. each pound contains 1188.3 B.t.u. The degree of superheat corresponding to 1186.3 B.t.u. is therefore found by interpolation to be

$$60 + \left[\frac{1186.3 - 1183.6}{1188.3 - 1183.6} \times (70 - 60)\right] = 65.7 \text{ deg. F.}$$

and the actual temperature would be

$$225.2 + 65.7, \text{ or about } 291 \text{ deg. F.}$$

Efficiency of Boiler and Grates—What would be the efficiency of a boiler and grate if the evaporation of 37,968 lb. of water from feed water at 170 deg. F. into dry saturated steam at 110 lb. per sq.in. gage pressure required the combustion of four tons of coal of a calorific value of 13,000 B.t.u. per lb.?

V. K. S.

Each pound of feed water at 170 deg. F. would contain

$$170 - 32 = 138 \text{ B.t.u. above 32 deg. F.}$$

and as a pound of dry saturated steam at 110-lb. gage pressure, or about 125 lb. per sq.in. absolute, contains 1190.3 B.t.u., then each pound of water evaporated into steam would require

$$1190.3 - 138 = 1052.3 \text{ B.t.u.}$$

so that under the conditions stated the evaporation of 37,968 lb. of feed water would require

$$37{,}968 \times 1052.3 = 39{,}953{,}726.4 \text{ B.t.u.}$$

Allowing 2000 lb. per ton, then in using four tons of coal the heat absorbed per pound of coal would be

$$\frac{39{,}953{,}726.4}{4 \times 2000} = 4994.2 \text{ B.t.u.}$$

As the efficiency of the boiler and grate would be equal to

$$\frac{\text{Heat absorbed per pound of coal}}{\text{Calorific value of 1 lb. of coal}}$$

the efficiency would be

$$\frac{4994.2}{13{,}000} = 38.41 \text{ per cent.}$$

Piston Speed Assumed in Pump Formula—What pump piston speed would have to be assumed for figuring pump capacity by the formula, Gallons pumped per minute = $d^2 \times 4$, in which d represents the diameter of water piston in inches?

K. H.

Without allowing for slippage or reduction of piston area by the piston rod, the delivery would be expressed by the formula:

$$(1)\ \text{Gallons per min.} = \frac{d^2 \times 0.7854 \times L \times n}{231}$$

in which

d = Diameter of water piston in inches;
L = Length of stroke in inches;
n = Number of single strokes per minute;
231 = Number of cubic inches per gallon.

Calling S = Piston speed in feet per min., then as

$$S = \frac{L}{12} \times n \text{ or } 12\,S = L \times n,$$

formula (1) might be written

$$(2)\ \text{Gallons per min.} = \frac{d^2 \times 0.7854 \times 12\,S}{231} = d^2 \times 0.0408 \times S$$

Therefore, the given formula would be true when

$$d^2 \times 4 = d^2 \times 0.0408 \times S,$$

i.e., when S = 98.04; or, in other words, the given formula would be correct for an assumed piston speed of 98.04 ft. per min. without any allowance for slippage or piston rod, which would be equivalent to assuming a piston speed of 100 ft. per min., with an allowance of

$$\frac{(100 - 98.04) \times 100}{100} = 1.96 \text{ per cent.}$$

reduction of capacity by slippage and piston rod.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

The Effect of Vacuum in Steam Turbines*

By G. Gerald Stoney

SYNOPSIS—An interesting article dealing with the thermal gains and losses due to vacuum in land and marine turbines.

The degree of vacuum which gives the same velocity ratio at the exhaust end as throughout the whole turbine is the vacuum under which the best results are obtained; consequently, a turbine designed for 29 in. vacuum, barometer 30 in., requires more rows of blades or wheels than one designed for 27 in., the number of rows or wheels of a given diameter in each case being proportionate to the B.t.u. available in the range between the initial and final pressures and temperatures through which the turbine works. There may be considerable latitude in the velocity ratio at the exhaust end without seriously affecting the available economy. Neglecting the effect of the reheat factor, which is small in modern high efficiency turbines, and also neglecting terminal losses, with 175 lb. absolute initial pressure and a superheat of 150 degrees, the gains per inch of vacuum in the B.t.u. available during adiabatic expansion are as shown in Fig. 1 and are:

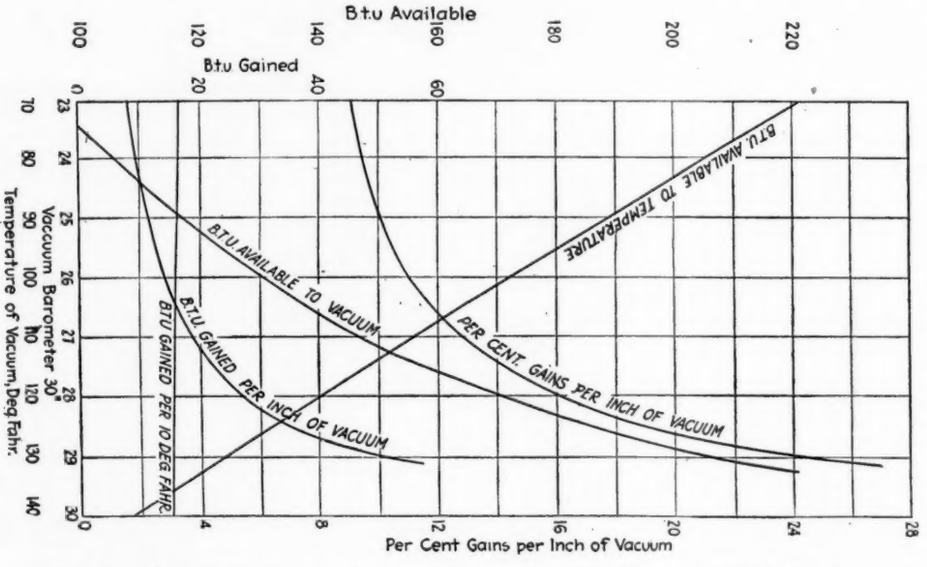


Fig. 1. Distribution of Heat during Adiabatic Expansion; Initial Pressure 175 Lb. Absolute; 150 Deg. F. Superheat

TABLE 1

Between 23 in. and 24 in., 3 per cent. or an increase of 9 B.t.u. on about 300 B.t.u. available at 23 in.

Between 24	in. and 25	in.,	3 per cent.	or 10 B.t.u.
Between 25	in. and 26	in.,	4 per cent.	or 12 B.t.u.
Between 26	in. and 27	in.,	5 per cent.	or 15 B.t.u.
Between 27	in. and 28	in.,	6 per cent.	or 21 B.tu..
Between 28	in. and 28½	in.,	8 per cent.	or 29 B.t.u.
Between 28½	in. and 28¾	in.,	9 per cent.	or 36 B.t.u.
Between 28¾	in. and 29	in.,	11 per cent.	or 42 B.t.u.
Between 29	in. and 29¼	in.,	13 per cent.	or 54 B.t.u.

For saturated steam at 175 lb. absolute, the figures are approximately the same.

In the case of an exhaust turbine working with, say 15 lb. absolute, the gains per inch of vacuum as shown in Fig. 2 are:

TABLE 2

Between 23 in. and 24 in., 9 per cent. or an increase of 10 B.t.u. on about 110 B.t.u. available at 23 in.

Between 24	in. and 25	in.,	10 per cent.	or 11 B.t.u.
Between 25	in. and 26	in.,	11 per cent.	or 13 B.t.u.
Between 26	in. and 27	in.,	12 per cent.	or 17 B.t.u.
Between 27	in. and 28	in.,	14 per cent.	or 22 B.t.u.
Between 28	in. and 28½	in.,	17 per cent.	or 30 B.t.u.
Between 28½	in. and 28¾	in.,	20 per cent.	or 38 B.t.u.
Between 28¾	in. and 29	in.,	23 per cent.	or 45 B.t.u.
Between 29	in. and 29¼	in.,	27 per cent.	or 57 B.t.u.

*From a paper read before the Institution of Mechanical Engineers, England.

For each degree Fahrenheit that the temperature due to the vacuum is reduced, there are approximately 1.5 more B.t.u. available, and this is approximately the case through the whole range considered in tables 1 and 2 and Figs. 1 and 2. These gains due to vacuum are attainable when the turbine can be suitably designed, but, in the case of high-speed, large output land turbines, allowance must be made for increased terminal losses.

For example, in a 3000-kw. land turbine at 3000 r.p.m. with an initial pressure of 175 lb., 150 degrees F. superheat and a vacuum of 29 in., the consumption will be about 12 lb. per kw.-hr., and the steam per hour will be 36,000 lb. or 10 lb. per second. The volume at exhaust, allowing for condensation, will be about 6000 cu.ft. per second. With present materials available, it is not in general customary to go above about 550 ft. per second for the mean velocity of the blades at the exhaust end, giving a mean diameter of 42 in., and as the blade height cannot be more than one-fifth of this, or 8.4 in., the area of the annulus is 7.7 sq.ft. The velocity of the steam leaving the blades through the restricted area will then be 780 ft. per second and involve a loss of 12 B.t.u., assuming that the velocity ratio and angle of the blades are such that the steam leaves them axially, as it should, to give the minimum loss. Even under these conditions there is still a gain of 6½ per cent. between 28 and 29 in. vacuum. For still larger powers these effects become more pronounced, until conditions are eventually reached in this class of turbine having a highly restricted exhaust end when an increase in vacuum causes no gain. It is the aim of designers to increase the limiting vacuum by using higher blade speeds and enabling an exhaust end of larger dimensions to be employed. This is undoubtedly a direction in which increased efficiency in large power high-speed turbines is to be found. The effect of increased blade speed is appreciable, as for a given vacuum the reduction in available gain varies inversely as the fourth power of the blade speed, since as the blade height cannot well be more than one-fifth of the mean diameter of the blades, the area at the exhaust will vary as the square of the diameter, or as the square of the mean blade velocity. Therefore the longitudinal velocity varies inversely as the square of the mean blade velocity, or the B.t.u. lost, inversely as the fourth power. Of course, the reduction can be halved by adopting a turbine with double flow at the exhaust, but this often introduces complications, although many economical land turbines of large power have been designed on these lines. Something can also be done by shaping the exhaust suitably, so as gradually to reduce the velocity of the steam on leaving the blades.

The case of reduced loads will now be considered. With throttle governing, the initial steam-pressure is reduced in accordance with a right-line law similar to the Willans law for the steam consumption, and it may be taken that in this case the initial pressure at no load is approximately atmospheric. If at full load the initial pressure is 175 lb. absolute, at half load it will be about 95 lb., and at quarter load, 63 lb. At half load, with a vacuum of 28 to 28½ in., the percentage gains in consumption per inch of vacuum would be increased by about one per cent., and at quarter load by about two and one-half per cent. above those given in tables 1 and 2, owing to the reduced B.t.u. available by reason of the reduced initial steam-pressure. The amounts of these gains will depend on the velocity ratio throughout the turbine, which has been assumed to be constant at full load.

At reduced loads with throttle governing, the velocity ratio will be approximately the same as at full load throughout the turbine, except near the exhaust end, where it will be greater at reduced loads. This may either slightly increase or diminish the efficiency at the exhaust end, according as the general velocity ratio is high or low, but in general the effect will be small.

With nozzle governing, the gains due to increased vacuum at reduced loads are somewhat less than with throttle governing, and the amount depends on the type of nozzle governing used, but broadly, at full load and at reduced loads the gains in consumption per inch of vacuum are more nearly equal with this type of governing. When a turbine is not bladed so as to give the full velocity ratio up to the exhaust end at full load, it is obvious that the above gains due to vacuum must be modified.

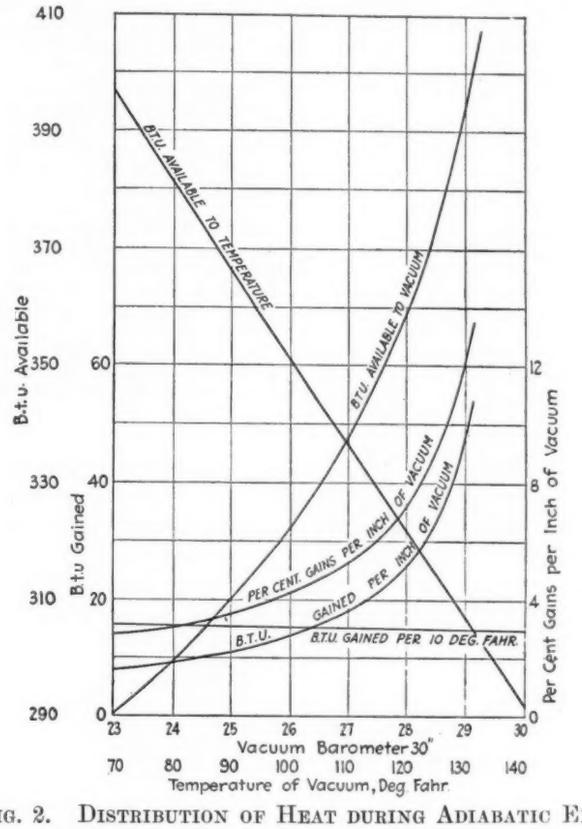

B.t.u. Available
B.t.u Gained
Per Cent Gains per Inch of Vacuum
B.T.U. AVAILABLE TO TEMPERATURE
B.T.U. AVAILABLE TO VACUUM
PER CENT. GAINS PER INCH OF VACUUM
GAINED PER INCH OF VACUUM
B.T.U.
B.T.U. GAINED PER 10 DEG. FAHR.
Vacuum Barometer 30"
Temperature of Vacuum, Deg. Fahr.

FIG. 2. DISTRIBUTION OF HEAT DURING ADIABATIC EXPANSION; INITIAL PRESSURE 15 LB. ABSOLUTE; SATURATED

Direct-coupled marine turbines especially, from considerations of weight and space, are often bladed to give uniform velocity ratio at full speed with about 26 in. vacuum, and from various causes many land turbines have been similarly bladed. In turbines so bladed and with ordinary steam pressures, it has been found by experience that the gain per inch of vacuum at full load is as follows:

Between 26	in. and 27	in.,	4	per cent.	or	12 B.t.u.
Between 27	in. and 28	in.,	5	per cent.	or	17 B.t.u.
Between 28	in. and 28½	in.,	6	per cent.	or	22 B.t.u.
Between 28½	in. and 29	in.,	7	per cent.	or	27 B.t.u.

In the turbines so bladed and at constant speed, as in land work, the velocity ratio at the exhaust end would automatically become at half load uniform with the rest of the turbine at about 28 in., and for quarter load, at about 28¾ in., so that in general it may be said that the theoretical gains as given will be completely obtained at reduced loads, but for strict accuracy, each case should be considered on its merits. It may be noted here that, although there is a decrease in efficiency at the exhaust end by having a cramped exhaust and low velocity ratio, there is but little loss when the exhaust end is large and has an unnecessarily high velocity ratio.

Marine turbines running at reduced speeds when the load is reduced may now be considered. Geared turbines can be and should be bladed for high vacuum, and the blading should be for nearly the highest vacuum obtainable in the waters in which the ship trades, as there is but little loss by running a turbine bladed for high vacuum at a lower one. For example, it should be bladed for 28½ to 29 in., the vacuum obtainable in home waters and the like, and not for 27½ to 28 in., which will be the vacuum obtainable in the tropics with a good condensing plant. In such turbines the full theoretical gain due to vacuum will be attained at full speed. At half speed and one-eighth power, if the consumption at full load is assumed to be 12 lb. per shaft horsepower, and at half speed 16 lb., the steam at half speed will be one-sixth that at full speed, and the velocity ratio three times that at full speed for the same vacuum, so that the exhaust end is amply large enough for the highest vacuum which can be attained, and therefore the gain due to increased vacuum will be somewhat more than that at full speed.

In most cases, blading a geared turbine for high vacuum as compared with low vacuum adds little to the weight, and generally only necessitates the exhaust end being made somewhat larger. It is important that the exhaust between the turbine blades and the condenser should be free and unrestricted, so that the loss of vacuum between the last row of blades and the steam space in the condenser should be a minimum. This applies to all classes of turbines.

It is equally important that the loss of vacuum between the steam space in the condenser and the air-pump suction should also be a minimum. In other words, given a condenser and an air pump of the highest efficiency, the difference in vacuum between the air-pump suction and exhaust end of the turbine should be reduced to an absolute minimum. The importance of this requirement should be carefully noted when analyzing data obtained from any particular turbine installation, whether land or marine, as otherwise erroneous conclusions may be formed. For example, if any of the many factors in design which influence the efficiency of any given installation as a whole are not provided for, it is futile to carry a vacuum higher than such provisions warrant: the consequent sacrifice in economy is measured in such cases by what is obtained and what is obtainable. Sometimes a definite velocity is fixed on for the velocity of the steam in the exhaust, but this has the difficulty that it depends on the vacuum for which the condenser is designed. A better way is to make the area of the exhaust have a definite ratio to the area of the annulus of the last row of blades, and in direct-coupled marine turbines this ratio is generally 1.5 to 1.7, but in geared turbines it can be increased to about 2.

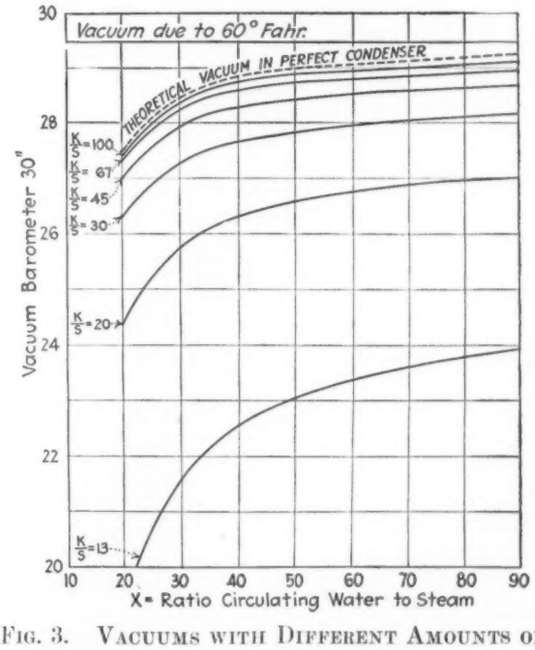


FIG. 3. VACUUMS WITH DIFFERENT AMOUNTS OF COOLING WATER

This means that, if the reduction of velocity can be made to take place gradually as in a diverging orifice, most of the terminal loss at the blades will be recovered, and much can be done in this direction by careful attention to having gradually diverging stream lines of steam from the blades to the condenser. A rule sometimes used on land is to have 18 to 20 lb. of steam per hour per square inch of exhaust area, and in many cases this works well. More careful attention is required in the future as to the shape of the exhaust, for at present many exhausts are so shaped as to cause considerable and unnecessary loss of vacuum.

The case of a direct-coupled marine turbine, only bladed for 26 in. at full speed, is rather different. Here, at full speed, the effect of vacuum will be as given on page 312, but the cases of half speed and one-eighth power have to be specially considered, more particularly on account of such devices as cruising turbines, etc. If we assume the steam per shaft horsepower with Parsons turbines to be 13 lb. at full speed and 21 lb. at half speed, and that the shaft horsepower at half speeds is one-eighth that at full speed, the steam per hour will be one-fifth that at full speed. Assuming that throughout the main turbines generally the velocity ratio is 0.5 at full speed, then at half speed the velocity ratio throughout the main turbines will be 0.25, except at the exhaust end, where it will be 1.25. This means that the full effect of vacuum will be obtained up to over 29 in., and on account of the low velocity ratio, the effect, provided the condensing plant will respond, will considerably exceed the theoretical at lower vacuums.

Up to the present the turbine alone has been considered, but in a complete installation, whether land or marine, there are many other factors to be taken account of. As increase in vacuum is associated with a correspondingly lower temperature of condensate, it follows that if the vacuum is raised

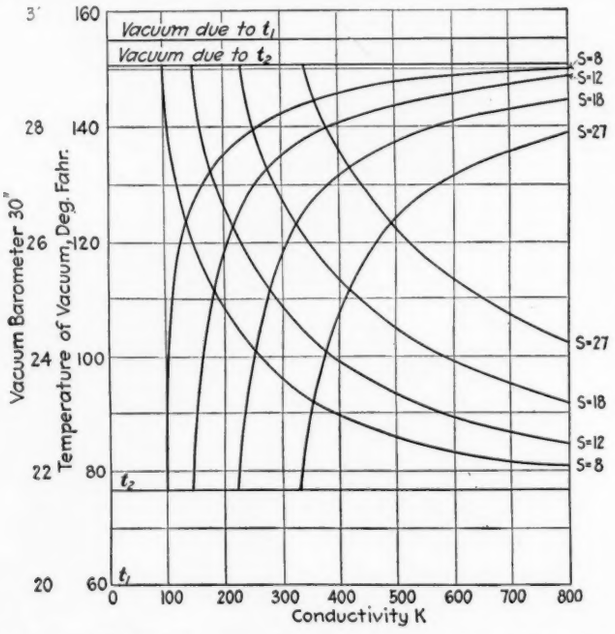


FIG. 4. VACUUMS AND TEMPERATURES WITH VARYING CONDUCTIVITY; CIRCULATING WATER (60 DEG. F.) 60 TIMES AMOUNT OF STEAM CONDENSED

and the condensate is delivered to the boiler at the same temperature at which it leaves the condenser, either the quantity of steam generated in the boiler per unit of coal is decreased or the quantity of coal per unit of steam generated is increased. If the difference between the temperature due to the vacuum and that of the condensate is taken as constant, a reduction of 10 degrees in the temperature of the feed-water delivered to the boiler is equivalent to an increase of about one per cent. in coal consumption per unit of steam generated, or

Between 26 in. and 27 in. = 1 per cent.
Between 27 in. and 28 in. = 1½ per cent.
Between 28 in. and 29 in. = 2 per cent.

Such a condition never arises in practice on land or at sea, as the condensate is invariably heated either by the waste gases from the boiler or by the exhaust steam from the auxiliary engines, or by both. Land installations usually include an economizer in the boiler uptake, and the practical requirement in such a case is that, in order to prevent sweating on the tubes, the feed water should be delivered to the economizer at a temperature of about 120 degrees F. But even at the highest vacuum there is usually sufficient exhaust steam from the auxiliaries to raise the condensate to this temperature, so that such a system represents the highest economy attainable with any given plant.

Marine installations present a different problem by reason of the large quantity of exhaust steam available from the auxiliary engines, and it may be noted that the heat in exhaust steam is used to the greatest advantage possible when it is redelivered to the boiler with the feed water. It follows that in order to attain maximum economy on shipboard, all the exhaust from auxiliary engines should be condensed by the feed water. A perfect installation from this point of view would be one in which the turbine works under the highest attainable vacuum with efficiency, and in which the exhaust steam is maintained at such pressure as will enable its heat to be wholly transferred to the feed water. In fact, the economic pressure for the auxiliaries to exhaust at is that in which the whole of their exhaust can be condensed by the feed. Obviously there should be no surplus exhaust, and if there is, it should never be discharged into the main condenser, because of the highly prejudicial effect of oil on the heat-transferring efficiency of the condenser tubes and on the vacuum. The direction in which progress is to be made on marine turbine installations would, therefore, appear to be, (a) high vacuum turbines; (b) high efficiency condensing plant; (c) economical auxiliaries; (d) efficient exhaust-steam feed-heaters.

In some cases where there is a surplus of auxiliary steam it is turned into the low-pressure turbine, and here there is an apparent partial recovery of the loss, but this arrangement has the defect of fouling both the turbines and the condenser with oil and reducing their efficiency, so that the power of the turbine may easily be reduced to a far greater extent than it can be increased by the use of such surplus steam. If, however, the steam is used in this way, it should be carefully filtered.

In order to consider further the effect of vacuum on an installation, it is necessary to consider the question of the condensers and the power necessary to work them. In a surface condenser there are three losses to be considered: (a) the temperature rise in the circulating water; (b) the resistance of the tube to heat transmission from the steam to the water; (c) air insulation of the condensing tubes.

These may be summed up in the apparent conductivity K of the condenser—that is, the B.t.u. transmitted per square foot per hour per degree Fahrenheit difference of temperature between the steam and the water.

Let

t_1 be the temperature in degrees Fahrenheit of the inlet water to condenser.
t_2 be the temperature in degrees Fahrenheit of the water leaving the condenser.
T be the temperature in degrees Fahrenheit due to the vacuum.
X the ratio of circulating water to steam condensed.
S steam condensed per square foot of condenser surface per hour.

(For convenience this is reckoned on the outside of the tubes.)

Then

$$K = 2.3 S X \log \frac{T - t_1}{T - t_2}$$

As it takes in ordinary practice about 1000 B.t.u. to condense each pound of steam we may write

$$1000 = X (t_2 - t_1)$$

and writing

$$T - t_2 = \delta$$

the equation becomes

$$K = 2.3 S X \log \frac{\delta + \frac{1000}{X}}{\delta}$$

As the maximum vacuum a condenser can produce is that due to the temperature of the exit water, the object of the designer is to have δ as small as possible. With a condenser in average conditions of cleanliness and efficient air withdrawal, the value of the conductivity K is obviously much higher than with inferior air extraction or a dirty condenser. The conductivity is also influenced by the load. For example, in a heavily loaded condenser, under the best conditions, a value of K of 1500 or even higher has been reached, while in condensers under low load it may be no higher than 300, so that this method of comparison requires to be used with some discretion.

Fig. 3 shows the vacuums obtainable with various values of K, S and X, and Figs. 4 and 5 the effect of conductivity at various rates of condensation for X = 60 and X = 30. All these are for an inlet temperature of 60 deg. F. and similar curves can be plotted for any other temperature, but as they are all similar in character, those for 60 deg. F. are alone given. It will be observed from Figs. 4 and 5 that the effect of reduced conductivity, such as is caused by air, is much more at high rates of condensation than at low, showing that the effect of a faulty air pump or dirty condenser is much more when the rate of condensation is high. It will also be seen that, approximately, the loss of vacuum below that theoretically obtainable depends only on the rate of condensation and on the amount of air insulation, and not on the quantity of circulating water—that is, that δ is approximately independent of X, always assuming a condenser free from oil on the outside of the tubes and scale on the inside. From the curves it follows that there is not much use in having more circulation water than about sixty to eighty times the

steam condensed at full load in home waters and the tropics respectively.

Figs. 4 and 5 also show the importance of having ample surface, and confirm what has often been found, that money put into a condenser of ample size is money well spent. Ample surface also gives a good margin to allow of the condenser getting dirty or for overloads. With a high rate of condensation, especially if the condenser is dirty, when an overload is required the vacuum will drop so much that not only is there often difficulty in getting the overload out of the turbine, but the boilers are still further overtaxed due to increased steam consumption causing the steam pressure to drop just at the time it is most important to have full pressure. It is usual in modern power stations to have a vacuum of about 29.1 in., barometer 30 in., with 50 deg. F. cooling water and circulating water 65 times the steam condensed, and 28 in. with 80 deg., 70 times, and it seems as if these conditions cannot be much improved upon, as, if the circulating water were increased in this case from 65 to 100 times the steam, the improvement in vacuum would only be about ⅛ in., and the pumps and circulating pipes would have to be increased 50 per cent. With 65 times as much and a moderate rate of condensation, such as 6 to 8 lb. per square foot at normal load, there is an ample margin for overload, an overload of 50 per cent. only reducing the vacuum by about half an inch.

In cases where there is not a supply of natural cooling water or only a restricted supply, or where cooling towers are used, the question of the best vacuum must be most carefully considered, and so many factors come into the case that each problem must be considered on its merits and alternative schemes worked out to find which is best. Such cases it is not proposed to deal with in this paper.

In the mercantile marine, the only question that has to be considered is the case of full speed at sea, and everything has to be arranged for the highest economy at that speed. In a recent geared turbine meat-carrying ship, the turbine is bladed for about 28½ to 28¾ in. vacuum, and the condensers have a surface of 8 lb. per square foot or 1½ sq.ft. per shaft horsepower, or equivalent to, say, 1.35 per i.h.p., and circulating water equal to 75 times the steam condensed, so as to provide for tropical waters. The vacuum is 29.1 in. with 50 deg. F. sea temperature, 28.8 in. with 60 deg. F., and 28 in. with 80 deg. F.

The weight of the Scotch boilers is 62 per cent., of the main turbines 12 per cent., of the condensers 3 per cent., of the circulating and air pumps with their pipes 5 per cent., and of other auxiliaries, pipes, etc., 18 per cent. of the total weight in engine and boiler rooms.

If the surface of the condensers were halved, giving 16 lb. per square foot, keeping the same circulating water, there would be a loss of vacuum of about one-half inch, and a saving on the total weight by the smaller condensers of 1½ per cent. This would increase the steam consumption by, say, 5 per cent., and therefore the weight of the boilers, by 5 per cent., and the total weight by 1½ per cent., not to speak of the 5 per cent. extra coal that would have to be carried. A reduction in the circulating water would also tend the same way. It is much more economical to save at the low temperature or condenser end of the system than at the high temperature or boiler end, and therefore to have as high an efficiency in the condensing plant as possible and turbines made to suit. The increase of weight in the condensers and turbines is much more than counterbalanced by the saving of weight in the boilers and coal to be carried. High efficiency in the condensing plant means not only sufficient surface and sufficient circulating water, but also most efficient air withdrawal, as, for example, by a steam jet.

The case of warships has also to be considered. In the case of a battleship with direct-coupled turbines, the weight of the water-tube boilers is 35 per cent., turbines 25 per cent., condensers 3 per cent., circulating and air pumps, etc., 4 per cent., and other auxiliaries, etc., 33 per cent. of the total engine and boiler room weights. The condensers condense at full power 18 lb. per square foot, and the circulating water is 65 times the steam. This gives, with 60 deg. F. sea temperature, a vacuum of 28¼ in. Direct-coupled warship turbines are bladed for about 26 in. for reasons given before, but with geared turbines bladed for higher vacuums, it is evident that it would pay to reduce the boilers and increase the condensers. At reduced speeds the condensers are lightly loaded, and here, as explained before, the highest vacuums can be taken advantage of by the turbines. With the lightly loaded condensers, the loss of temperature and vacuum due to the conductivity between the water and the steam through the tubes becomes small, and the important point is efficient air withdrawal.

At half speed or one-eighth power the condensers are only loaded to about 4 lb. per square foot, and as the vacuum is generally only about 28½ in., this means a conductivity of about 150 as against 600 to 800 B.t.u. at full load. But if greater care were taken to install air-withdrawing apparatus of the highest efficiency and ample capacity, such, for example, as is obtainable with a steam-jet combination, this vacuum could be raised to 28¾ or 29 in. with sea water at 60 deg. F., provided the condenser was of suitable design, thereby effecting a gain of at least 3 per cent. on the coal consumption, an amount which would far outweigh the comparatively slight additional cost and weight of the apparatus. This gain is independent of the drop of temperature of the condensate, as at low powers there is always more exhaust steam available than can be condensed by the feed water. Other types of warships can be similarly considered, but the case of the destroyer is especially difficult, as it is essentially a compromise, and here it has been considered economical to load up the condensers at full speed to about 27 lb. per square foot and reduce the circulating water to about fifty times.

With the advent of geared turbines the case becomes different, since they can be bladed for high vacua with little increase in the weights and sizes of the turbines, and it is clear that the greatest benefits from the highest vacua will be found. It is to be expected that in such cases there will be a large increase in the surface of the condensers and

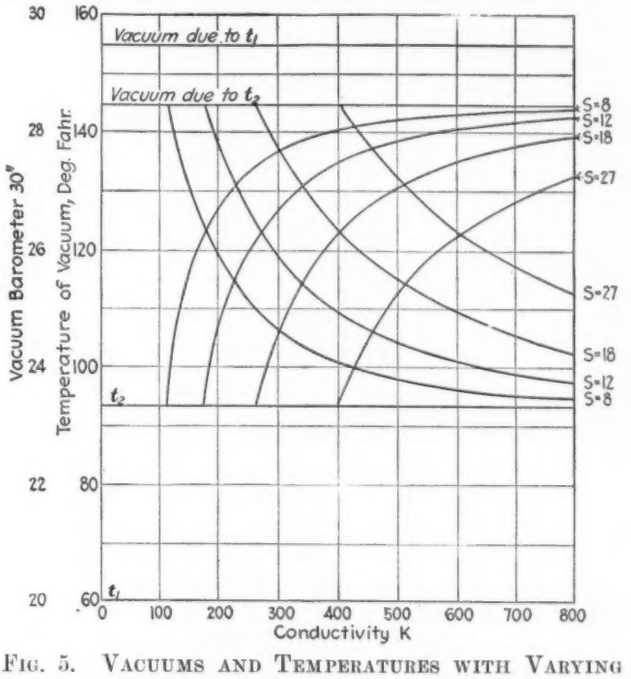


FIG. 5. VACUUMS AND TEMPERATURES WITH VARYING CONDUCTIVITY; CIRCULATING WATER (60 DEG. F.) 30 TIMES AMOUNT STEAM CONDENSED

improvement in air withdrawal, with a consequent reduction in the boilers and fuel carried.

The aims of an efficient condenser are to have the maximum of heat transfer from the steam to the circulating water—that is, a minimum difference between the temperature due to the vacuum and the temperature of the circulating water leaving the condenser, and also to deliver the condensate to the hotwell as near the temperature due to the vacuum as possible. And here it is important to consider the steam consumption of the auxiliaries and the air-withdrawal arrangements which comprise air pumps in some form, together with the withdrawal of the condensate from the condenser. It is not proposed to enter into the different types of air pumps, but as the driving power of these pumps is at most only about one per cent. of the power of the turbine at full load, and in general much less, the importance of the steam used per unit of power required for driving an air pump is negligible compared with its vacuum-producing qualities. The steam required by the circulating pumps depends on the steam consumption W in lb. per water horsepower-hour, of the engine driving the circulating pumps, the ratio X of the circulating water to the steam condensed, and the total head h in feet on the pumps. We have then

$$\text{percentage of steam used by pump} = \frac{WXh}{20{,}000}$$

For example, if we take W = 60, X = 60, and h = 20 feet, we have percentage used = 3.6.

For X = 30, the percentage is 1.8.

The difference in the hotwell temperature, between condensers using these quantities of circulating water, is about 17 deg. F., so that without allowing for condensation it may be said that in this case the temperature of the feed, after it has condensed the steam from the circulating pump, is largely independent of the quantity of circulating water, and this has to be considered in making up the final balance sheet, which alone enables the most difficult problem of the best vacuum for any particular installation to be considered.

Midwinter Convention of A. I. E. E.

The third midwinter convention of the American Institute of Electrical Engineers was held at the Engineering Societies Building, New York City, on Feb. 17 to 19. In his opening address, President Paul M. Lincoln referred to the great service of an engineering society in promoting exchange of ideas, the idea usually being worthless unless passed along to receive the benefit of other minds.

The application of electric motors was the topic of the first session, D. B. Rushmore opening it with a paper on "The Characteristics of Electric Motors." This paper, in the nature of an outline, was followed by carefully prepared discussions on different types of motors, each speaker selecting a particular type.

On Wednesday afternoon five papers were presented: "Effect of Moisture in the Earth on Temperature of Underground Cables," by S. E. Imlay; "Oil Circuit-Breakers," by K. C. Randall; "Comparison of Calculated and Measured Corona Loss Curves," by F. W. Peek, Jr.; and "A 100,000-Volt Portable Substation," by C. I. Burkholder and Nicholas Stahl.

Three papers comprised the Thursday morning program: "Distortion of Alternating-Current Wave Form Caused by Cyclic Variation in Resistance," by Frederick Bedell and E. C. Mayer; "Dimmers for Tungsten Lamps," by A. E. Waller; and "Searchlights," by C. S. McDowell.

The Friday morning session was devoted to "Electrical Precipitation," three papers being presented, namely: "Theory of the Removal of Suspended Matter from Fluids," by W. W. Strong; "Theoretical and Experimental Considerations of Electrical Precipitation," by A. F. Nesbit; and "Practical Applications of Electrical Precipitation," by Linn Bradley. The last technical paper was on "Electrical Porcelain," by E. E. F. Creighton.

STATUS OF THE ENGINEER

The most interesting feature of the convention program was the discussion on Wednesday evening of the "Status of the Engineer." The list of speakers showed that care had been exercised to have the subject dealt with from several angles. A. C. Humphreys, president of Stevens Institute, and Prof. G. A. Swain, of Harvard, represented those responsible for the training of engineers; E. W. Rice, Jr., president of the General Electric Co., and E. M. Herr, president of the Westinghouse Electric & Manufacturing Co., represented the largest employers of engineers, and L. B. Stillwell, H. G. Stott and J. J. Carty represented successful engineers now actively engaged in the profession.

Mr. Stillwell in opening the discussion predicted that if the engineer would take a more active part in public affairs, proper recognition would follow. To this end, however, more liberal and less technical education is needed in the colleges. He charged the national engineering societies with having failed to raise the prestige of engineers, pointing out by way of comparison what the Bar Association has done for the legal profession. In this connection he suggested that the engineering societies jointly formulate a code of ethics, which should be enforced strictly, even to the point of expulsion from membership for any violations of the rules. Furthermore, the societies should adopt a policy with regard to license legislation and also advise on public questions such as water-power development, etc.

Mr. Rice in taking up the discussion reviewed some of the engineering achievements and their effects upon modern civilization; yet engineers have practically no voice in running the Government. In the present Congress there is only one engineer out of a total of 435 members in the House and none in the Senate, about 70 per cent. being lawyers. In view of the number of public problems directly or indirectly related to engineering, which are up for consideration it would seem advisable that the representation include some who have had engineering training. "This training," said Mr. Rice, "makes a man search for facts and represents a blending of conservatism and radicalism."

E. M. Herr, speaking from the standpoint of the manufacturer, believed that mathematical training and analysis tend to unfit a man to deal with the human element, and attributed to this fact the failure of many engineers in successfully handling men. He advised the application of the "Golden Rule" as the best solution to this phase of the problem.

Speaking from his experience as an educator, Doctor Humphreys was of the opinion that boys now come to college poorly prepared, because much of their time has been taken up in the preparatory schools with irrelevant studies. He believed that the engineer should receive a more liberal education, but did not advocate a six-year course, adding: "The sooner a man gets out of college after learning the fundamentals, the sooner will he become a specialist." With regard to present regulative tendencies of the government through commissions, Doctor Humphreys seemed to think that it was being carried too far, and often took the form of control rather than regulation. He especially lamented the apparent disposition in some circles to regard business as dishonest, and expressed the belief that with engineers occupying a prominent part in the Government and on commissions, this country would be brought back to a sane regulation of its affairs.

Professor Swain endeavored to show why engineers as a class are not recognized to the same extent as men in many other professions. "Leadership," he said, "depends upon personal qualities, some inherent and others received by training, and it is doubtful whether engineers think straighter than lawyers or business men, or have greater breadth of view. In fact, the engineer is apt to confine himself too closely to technical subjects to the exclusion of outside affairs." As a remedy for this condition, he suggested a broader curriculum in the technical schools, with less details, which can be learned later, and a better training in English and in such liberal subjects as will promote personal qualities. The speaker believed the remuneration in engineering to be fair and comparable with the average in other professions, although admitting that large fees were the exception rather than the rule in engineering. The ability of doctors and lawyers to command large fees was probably due to the character of their work appealing to the emotions, or in the case of the architect to the vanity of the client; whereas in the case of the engineer his work is a cold business proposition and its value is measured accordingly.

Mr. Stott seemed to think the present status of engineers fairly satisfactory, although he believed that engineers in the government service are often deprived of proper credit by their superiors, who often have no technical training whatever. He believed engineers should specialize and, in doing so, should follow their own inclinations.

Mr. Carty spoke of the engineer as concerned with problems of organization, but warned against "scientific management" masquerading as engineering.

The entertainment included a trip to the new power house of the United Electric Light & Power Co. on Thursday afternoon and a dinner dance at the Hotel Astor that evening.

Boiler Inspectors' Banquet

Probably the most successful and most enjoyable so far was the fifth annual dinner of the New York Section of the American Institute of Steam Boiler Inspectors, held at Rectors in New York, Feb. 20. The attendance was large, 110, made up of people interested directly or indirectly in the inspection of boilers. In the role of toastmaster Michael Fogarty distinguished himself as usual. The speakers in addition to the incoming, retiring and past officers of the Institute were: Dr. D. S. Jacobus, of the Babcock & Wilcox Co., who rehearsed something of the history of the American Society of Mechanical Engineers' Proposed Boiler Code, with which he, as a member of the advisory committee, was very familiar; Fred R. Low, editor of "Power," and Herman Van Ormer and John H. Gleason, both of the Boston office of the Hartford Steam Boiler Inspection & Insurance Co., and Inspector Lanigan of the New York boiler squad.

Shrinkage During Solidification—A few exceptions to those substances which undergo the usual shrinkage during the process of solification are pointed out by the "Mechanical World." These exceptions include cast iron, antimony and bismuth. When melted cast iron is poured into a mold it expands in solidifying and presses into every part of the mold. The pattern in the casting is, therefore, as clearly traced as it was in the mold. After it has changed from a liquid to a solid, however, the order is reversed, and in cooling down from the first stage of solidification to normal temperature a shrinkage of about ⅛ in. to the foot takes place.

A clear-cut cast cannot be obtained from lead, which is one of the reasons why antimony is made a constituent of type metal. Gold coins have to be stamped; they cannot be cast so as to produce a clear-cut design, for the same reason.

Opening of the Exposition

At noon, Pacific Coast time (3 p.m. Eastern time), Saturday, Feb. 20, President Wilson pressed a button in Washington giving an electric signal for the opening of the Panama-Pacific International Exposition in San Francisco. In last week's issue a number of the features of the Fair were given as most likely to interest "Power" readers, and more is yet to be printed of certain of the exhibits and the lessons to be drawn from them with respect to past, present and future.

As the day of opening dawned, the city which had been looking forward to it so long seemed fairly to break out with its pent-up enthusiasm. For an hour from 6:30 o'clock, all means of noise-making seemed to be in commission, from steam whistles, automobile horns, car gongs and church bells down to rattles, tin horns and the usual facilities available to the individual. A large crowd had gathered on the grounds hours before the opening, and before the end of the day the attendance had broken all records of like kind, exceeding 300,000, in spite of the clouds and showers.

The dedicatory ceremonies were short and simple. The citizens, headed by Governor Hiram W. Johnson and Mayor Rolph, representing the state and city, were welcomed to the grounds by the officers and directors of the Exposition and officers of the Federal Government. Addresses were delivered by President C. C. Moore of the exposition, Dr. Frederick J. V. Skiff, director-in-chief; Governor Johnson, Secretary of the Interior Frank K. Lane representing President Wilson, and a few others. Invocations and benedictions were pronounced by clergymen representing the Roman Catholic, Protestant and Jewish faiths. President Wilson forwarded a message of congratulation to the directors, which was read to the crowd.

At the Washington end the ceremony was staged in the East Room of the White House, where places were reserved for members of the Cabinet and the California delegation in Congress. Assistant Secretary of the Navy Roosevelt represented the Government Exposition Board. At the President's touch, two signals were sent, one by telegraph to San Francisco and one by wireless to Tuckerton, N. J., and relayed thence to San Francisco.

With the receipt of the signal the Fountain of Energy was started, flags of all the nations were raised on the various poles and pinnacles, signal bombs were exploded from towers, an aëroplane circled the Tower of Jewels, scattering doves of peace, and the doors of the Palace of Machinery swung open, revealing the exhibits within in motion.

PERSONALS

James Smieton, Jr., who has been acting in that capacity for the past year, has been appointed secretary-treasurer of the Society for Electrical Development.

N. H. Brown, until recently Chicago representative of the Bury Compressor Co., has been made sales engineer of the Erie Pump & Equipment Co., Erie, Penn., successor to the Northern Equipment Co. and the Erie Pump & Engine Works.

John S. Huey, formerly with the Allis-Chalmers Manufacturing Co., and more recently with Woodward, Wight & Co., has been appointed by the Kerr Turbine Co., Wellsville, N. Y., as its district sales agent for Louisiana and southern Mississippi. His office is in Room 418, Hibernia Bank Bldg., New Orleans, La.

Matthew T. Slattery, an Ohio state boiler inspector in general charge of the district which includes Cleveland, has been appointed commissioner of the Cleveland smoke prevention division to succeed E. P. Roberts, whose resignation was recently noted.

William M. Davis, an occasional contributor to "Power," has accepted a position as efficiency engineer for the Texas Co. He will have a force of a dozen or more in service, who under his direction will be trained to make surveys and inspections of customers' plants and prepare reports showing how to obtain the best service with the lubricants in use.

John W. Exler has been elected president of the James Lappan Manufacturing Co., of Pittsburgh, Penn. Mr. Exler has been employed as a boiler maker and iron worker for over 40 years. In the '80s he was engaged as foreman with the Niles (Ohio) Boiler Co., and later with Reeves Bros. Co., at Alliance, Ohio. He has also filled some important positions with large Pittsburgh manufacturing concerns.

A. S. Baldwin has resigned as manager of the Best Manufacturing Co., to take effect not later than Apr. 1. This company has recently been absorbed by the Kennedy-Stroh Corporation, which has its complete organization. Mr. Baldwin was for two years superintendent of the American & British Manufacturing Co., Bridgeport, Conn.; four and one-half years general superintendent of the Driggs-Seabury Ordnance Corporation, Sharon, Penn., and for three years general manager of the Alberger Pump & Condenser Co., Newburgh, N. Y. For the present his address is General Delivery, Oakmont, Penn.

Erasmus Darwin Leavitt, of Cambridge, Mass., has been elected an honorary member of the American Society of Mechanical Engineers, of which he was the second president. Mr. Leavitt was assistant engineer in the United States Navy from 1861 to 1867, consulting engineer for the Calumet & Hecla Mining Co. from 1874 to 1904, and has acted as consulting engineer in many large capacities. He is a member of all of the professional engineering societies, and was awarded the degree of Doctor of Engineering by Stevens Institute of Technology in 1884.

ENGINEERING AFFAIRS

Technical Associations' Secretaries—Technical societies and associations have become so numerous and important that a society of Technical Associations' Secretaries has been organized, and held its first annual meeting in the rooms of the American Society of Mechanical Engineers, Engineering Societies Building, 29 West 39th St., New York, on Saturday, Feb. 27.

Transactions of the International Engineering Congress (to be held Sept. 20-25, at San Francisco, Calif.)—Volume I will comprise a unique series of papers on the engineering of the Panama Canal. The various topics and subdivisions of the work have been arranged by Col. G. W. Goethals, chief engineer of the canal, and now governor of the Canal Zone. Col. Goethals has also selected the author for the treatment of each paper, and he will himself contribute the introductory chapter. The various authors are, in general, the officers who were in direct charge of the actual work of construction, and the collection of papers thus becomes a first-hand account of the engineering of the canal, written by the men who were in immediate and responsible charge of the undertaking. There will be 24 papers in all, profusely illustrated, 22 of which deal with actual constructive and engineering problems connected with the work, one with the preliminary work in municipal engineering in the Canal Zone, and one with the commercial and trade aspects of the canal. This volume can be obtained only through enrollment in the congress. The transactions of the congress as a whole will include from seven to nine other volumes, covering all important phases of engineering work. Membership in the congress, with the privilege of purchasing any or all of the volumes of the proceedings, is open to all interested in engineering work. Full particulars can be had upon application to W. A. Cattell, secretary, 417 Foxcroft Building, San Francisco, Calif.

NEW PUBLICATIONS

HOW TO RUN AND INSTALL A GASOLINE ENGINE. By C. Von Culin. Published by Norman W. Henley Publishing Co., 132 Nassau St., New York City, 1915. Revised Edition. Size, 3¼x6 in.; 96 pages, illustrated. Price, 25c.

This little book is printed as a pocket instructor for the beginner or the busy man who uses a marine engine for pleasure and who does not have the time or the inclination for a complete technical perusal of the subject. The method of treating the various topics by the author is such that a man who has no technical knowledge of a gasoline engine may obtain enough information to enable him to operate one successfully, either of the two- or four-stroke-cycle type. Many pointers are given regarding the causes of trouble in gasoline engines, and the remedies. If the reader absorbs all the information contained in the book he should be able to operate his gasoline engine without any particular trouble. The book is well illustrated and contains a remarkable amount of information for such a small volume.

HAND FIRING SOFT COAL UNDER POWER-PLANT BOILERS is the title of Technical Paper 80, by Henry Kreisinger, issued by the U. S. Bureau of Mines, as an aid to firemen throughout the United States. Copies may be obtained without cost by addressing the Director of the Bureau of Mines, Washington, D. C.

The paper, which contains descriptions of methods of firing

soft coal under power-plant boilers and of handling fires so as to have the least smoke and to get the most heat from the fuel, seeks to meet the needs of the men, many without technical education, who are employed in small plants. For this reason the language used is plain and simple, and technical terms have been avoided as far as possible.

Under "General Directions on Firing Soft Coal," the following statements are made:

When burning bituminous coal under power-plant boilers the best results are obtained if the fires are kept level and rather thin. The best thickness of the fires is four to ten inches, depending on the character of the coal and the strength of draft. The coal should be fired in small quantities and at short intervals. The fuel bed should be kept level and in good condition by spreading the fresh coal only over the thin places where the coal tends to burn away and leave the grate bare.

Leveling or disturbing the fuel bed in any way should be avoided as much as possible; it means more work for the fireman and is apt to cause the formation of troublesome clinker. Furthermore, while the fireman is leveling the fires a large excess of air enters the furnace, and this excess of air impairs the efficiency.

The ashpit door should be kept open. A large accumulation of refuse in the ashpit should be avoided, as it may cause an uneven distribution of air under the grate. Whenever a coal shows a tendency to clinker, water should be kept in the ashpit. All regulation of draft should be done with the damper and not with the ashpit doors.

In firing, the fireman should place the coal on the thin spots of the fuel bed. Thin and thick spots will occur even with the most careful firing, because the coal never burns at a uniform rate over the entire grate area. In places where the air flows freely through the fuel bed the coal burns faster than in places where the flow of air is less. The cause of this variation in the flow of air through the different parts of the fuel bed may be differences in the size of the coal, accumulations of clinker, or the fusing of the coal to a hard crust. Where the coal burns rapidly, the thin places form.

Before throwing the fresh coal into the furnace the fireman should take a quick look at the fuel bed and note the thin spots. In a well-kept fire these spots can be usually recognized by the bright hot flame. The thick places have either a sluggish smoky flame or none at all. In order to place the coal over the thin places the fireman should take a rather small quantity of coal on his scoop, for it is much easier to place the coal where it is needed with small shovelfuls than with large ones.

The coal should be placed on the thin places in rather thin layers. If the fireman attempts to fill up the deep hollows in the fuel bed at one firing, the freshly fired coal may fuse into a hard crust, thus choking the flow of air, causing the fuel to burn slowly and starting new high places. If the high places in the fuel bed are missed on one or two firings the hard crust at the surface will gradually burn through or crack, thus allowing more air to flow through, and the place will get back to its normal condition. Of course, if the high place in the fuel bed is caused by clinker the flow of air will not be free until the clinker is removed with the fire tool. Whatever may be the cause of the high places in the fuel bed, the fireman should remember that they are places where the coal does not burn. There is no use in putting coal on such a place.

If the firings are too far apart the coal in the thin spots may burn out entirely, allowing a large excess of air to enter the furnace in streams. If those streams of air are not properly mixed with the gases from the coal, only a small percentage of the air is used for combustion, and most of it passes out of the furnace, depriving the boiler of considerable heat. If, for instance, air enters the furnace at atmospheric temperature, say 75 deg. F., and leaves the boiler at about 575 deg. F., it carries away the heat that was absorbed in raising its temperature 500 deg. F. This heat is lost to the boiler. Another loss of heat occurs when holes form in the fuel bed, because pieces of unburned coal fall through the grate when the fireman attempts to cover the holes with fresh coal. Therefore, in order to avoid the formation of holes, firings should be made at short intervals, particularly if, for any reason, the fuel bed must be kept thin.

NEW PUBLICATIONS OF THE BUREAU OF MINES

Fourth Annual Report of the director of the Bureau of Mines to the Secretary of the Interior, for the fiscal year ended June 30, 1914; 101 pages.

Bulletin 84, Metallurgical Smoke. By Charles H. Fulton; 92 pages; 6 plates; 14 figures.

Bulletin 85, Analyses of Mine and Car Samples of Coal Collected in the Fiscal Years 1911 to 1913. By A. C. Fieldner, H. I. Smith, A. H. Fay and Samuel Sanford; 44 pages; 2 figures.

Technical Paper 80, Hand-firing Soft Coal under Power-Plant Boilers. By Henry Kreisinger; 83 pages; 32 figures.

Miners' Circular 21, What a Miner Can Do to Prevent Explosions of Gas and of Coal Dust. By G. S. Rice; 24 pages.

Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

A Simple Test for Animal and Vegetable Contents in oil is to shake up with the sample in a test tube about one-fifth or one-quarter of its own volume of a saturated solution of borax in water. The presence of animal or vegetable matter is indicated by an opaque white line of saponification, which forms between the water and the oil after they are allowed to separate. Paraffin in oil may be detected by heating a sample up to 450 deg. The presence of paraffin is indicated by a material darkening in the color of the oil.

TRADE CATALOGS

Chain Belt Co., Milwaukee, Wis. General Catalog No. 56. Elevating, conveying and concrete machinery. Illustrated, 304 pp., 6x9 in.

Jeffrey Mfg. Co., Columbus, O. Bulletin No. 147. Swing hammer pulverizers for coal, etc. Illustrated, 48 pp. Bulletin No. 167. Belt conveyors. Illustrated, 24 pp.

Wm. B. Scaife & Sons Co., 221 First Ave., Pittsburgh, Penn. Pamphlet. "Pure Clear Ice." Illustrated, 12 pp., 5x8 in. Pamphlet. Central Power Station Economy. Illustrated, 8 pp., 4x9 in.

CATALOGS WANTED

The Compressed Gas Manufacturers' Association, Incorporated, requests manufacturers of valves, cylinders, recording gages, filling and weighing stands and of material and appliances which enter into the manufacture, transportation and sale of compressed gases to send catalogs, price lists and full descriptive details to the secretary of the association, 25 Madison Ave., New York City.

BUSINESS ITEMS

The Kerr Turbine Co., Wellsville, N. Y., has appointed W. E. Storey as its Toronto, Canada, representative, with offices in the Kent Building. Mr. Storey was formerly identified with the Underfeed Stoker Co., and more recently with Goulds Manufacturing Co.

The Nelson Valve Co., of Chestnut Hill, Philadelphia, has issued a revised edition of its twelve page folder entitled "Double Disc vs. Solid Wedge." It contains an interesting history of the development of the gate valve. Copies will be mailed on request.

A very attractive circular has just been issued by the Homestead Valve Mfg. Co., Pittsburgh, Penn., illustrating many styles of Homestead Valves. "Here is Your Opportunity to End Your Valve Troubles" is the title. It is being sent to steam users everywhere.

The Yarnall-Waring Co., of Chestnut Hill, Philadelphia, has recently secured an order for "Lea" V-notch meters from the Philadelphia Electric Co., for its great new Christian St. power house, for what is believed to be the largest feed-water V-notch metering installation in the world, comprising two 800,000-lb. per hr. "Lea" V-notch recording meters combined with two 20,000-hp. Webster feed-water heaters and purifiers, to heat and measure 20,000 boiler hp. of feed water. Make-up water for this plant will be measured by a 175,000-lb. per hr. "Lea" V-notch recording meter.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance **Positions Open,** (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Opportunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books), **For Sale,** 5 cents a word, minimum charge, $1.00 an insertion.

Count three words for keyed address care of New York; four for Chicago Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A.M. Tuesday for ensuing week's issue Answers addressed to our care, Tenth Ave. at Thirty-sixth Street, New York or 1144 Monadnock Block, Chicago will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. P

POSITIONS OPEN

SALESMAN wanted, one who sells to wholesale plumber and hardware suppliers, to sell machinery cotton waste. P. 439, Power.

DESIGNER, thoroughly capable of laying out a complete line of evaporators. Reply, stating age, experience, salary expected, references, etc., P. 438, Power.

DESIGNER AND CHECKER, with experience on condensers and their auxiliaries; only first-class men need apply; state age, experience and salary expected. P. 437, Power.

HIGH-CLASS CHIEF ENGINEER, for modern, medium-sized packing house in Middle West; must have experience and thorough knowledge of boilers, refrigeration, electricity and packing-house machinery. P. 442, Power, Chicago.

POSITIONS WANTED

ENGINEER (marine and stationary certificates), familiar with boilers all types, reciprocating engines, turbines and usual electric and refrigerating equipment; experienced and competent as chief; New York City or vicinity. P. W. 444, Power.